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Monterey, California

THESIS

NAVAL POSTGRADUATE SCHOOL
SCHEDULING SUPPORT SYSTEM (NPS^4)

by

Jeffrey S. Nolan
and
Phillip D. Youngblood

March 1992

Thesis Co-Advisors: Daniel R. Dolk
David A. Erickson

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Naval Postgraduate School Scheduling Support System (NPS^4)

by

Jeffrey S. Nolan
Lieutenant, United States Navy
B.S., Northwestern University, 1986

and

Phillip D. Youngblood
Lieutenant Commander, United States Navy
B.S., University of Hawaii, 1977

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March 1992

Authors: Jeffrey S. Nolan

Phillip D. Youngblood

Approved by: Daniel R. Dolk, Thesis Co-Advisor

David A. Erickson, Thesis Co-Advisor

David R. Whipple, Chairman
Department of Administrative Sciences

ABSTRACT

A decision support system, the Naval Postgraduate School Scheduling Support System (NPS^4), is proposed to assist schedulers in developing schedules for students, instructors and classrooms for the academic quarter and final examination week. Historical aspects of course scheduling at the Naval Postgraduate School (NPS) are described, and the current course scheduling process (1992) at NPS is analyzed. Its requirements, high-level specifications, and design elements are described in detail. An analysis of alternatives, future considerations for designing and implementing the proposed decision support system, and a prototype user interface are presented.

THESIS DISCLAIMER

The reader is cautioned that the decision support system detailed in this research is a proposal only. While every effort has been made to document the scheduling process at the Naval Postgraduate School in the fullest detail, further design of the Naval Postgraduate School Scheduling Support System (NPS^4) should be accompanied with the validation of each step by the current schedulers. Furthermore, while the authors experienced wholehearted support for our research among almost all personnel associated with the NPS scheduling process, the proposed decision support system has not been officially supported, nor has it been funded or thoroughly documented. All of these requirements would have to met before official development and implementation can occur.

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We extend our appreciation to thesis advisors Professor Dan Dolk and Professor Dave Erickson, who contributed their individual expertise in the fields of information and computer systems, gave us free rein to tackle this project as we saw fit, and assisted us when we really needed it.

Finally, we'd like to give a special thank you hug to our wives, Elaine Nolan and Deborah Youngblood, without whose understanding and support this could not have been possible.

I. INTRODUCTION

A. NAVAL POSTGRADUATE SCHOOL (NPS)

The Naval Postgraduate School at Monterey, California, is an academic institution of higher learning and research operated under the direction of the Chief of Naval Operations. Its primary purpose is to increase the combat effectiveness of U.S. and allied armed forces by providing post-baccalaureate degree programs to qualified students in areas not usually available at other educational institutions, and by conducting research that actively supports U.S. armed forces operations. NPS prepares students to introduce current ideas and state-of-the-art technologies back into their respective services. [Ref.1:p.1-7]

1. Students

The NPS student body is comprised of U.S. military officers from the Navy, Marines, Army, Air Force and Coast Guard, officers from almost 30 allied countries, and some U.S. military enlisted personnel and federal civilian employees. Most students pursue study and research programs satisfying both Masters or Doctorate degree requirements and further requirements that earn them a military subspecialty code. Students are selected on the basis of a strong academic background and proven outstanding professional performance.

They attend NPS as a job assignment and are paid as they would be at any shore-based command, their education fully funded except for textbooks and other materials. [Ref.1:p.1-12]

2. Administration and Faculty

The administration of NPS is a cooperative venture between military and civilian factions. Civilian-dominated academic departments prepare and offer courses. A majority (94%) of their faculty members are civilians with Doctorate degrees. Military Curricular Officers develop curricular programs of study and direct students through chosen programs to ensure students complete both academic and professional requirements. Academic Associates work with Curricular Officers to ensure curricular programs are academically sound with respect to degree requirements. A Management Analyst administers the collection of data used in the scheduling process, and Class Schedulers construct course schedules from the collected data. Figures 1.1-1.3 show the relationships between the principal parties involved in the scheduling process at three time periods relevant to this research. [Ref.1:p.14-15] and [Ref.2]

B. SCHEDULING AT NPS

The NPS academic year is divided into four quarters. Constructing schedules for each quarter requires a cooperative effort from several groups of people over four phases of the scheduling process [Ref. 3]:

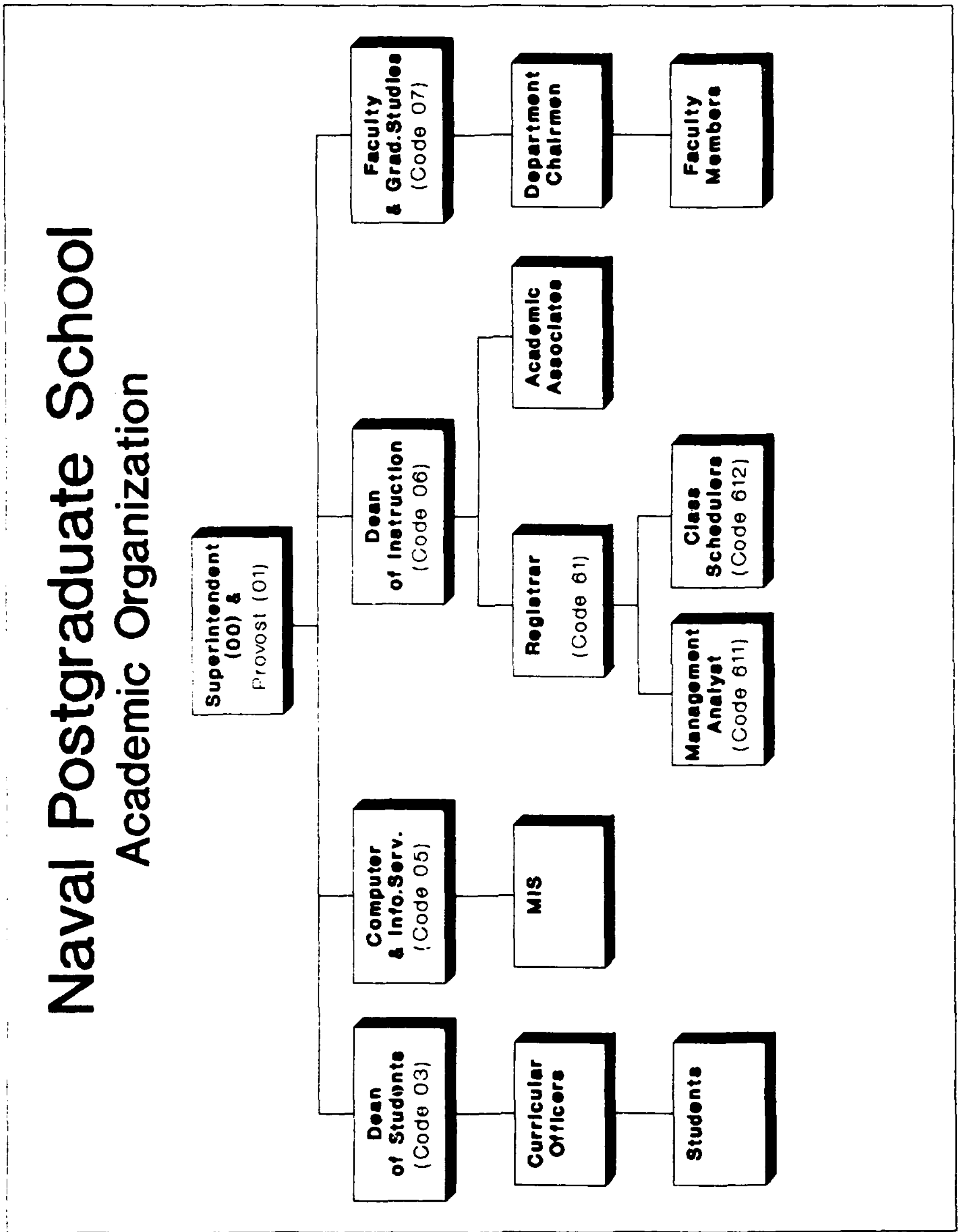

Figure 1.1 Naval Postgraduate School
Academic Organization (1992)

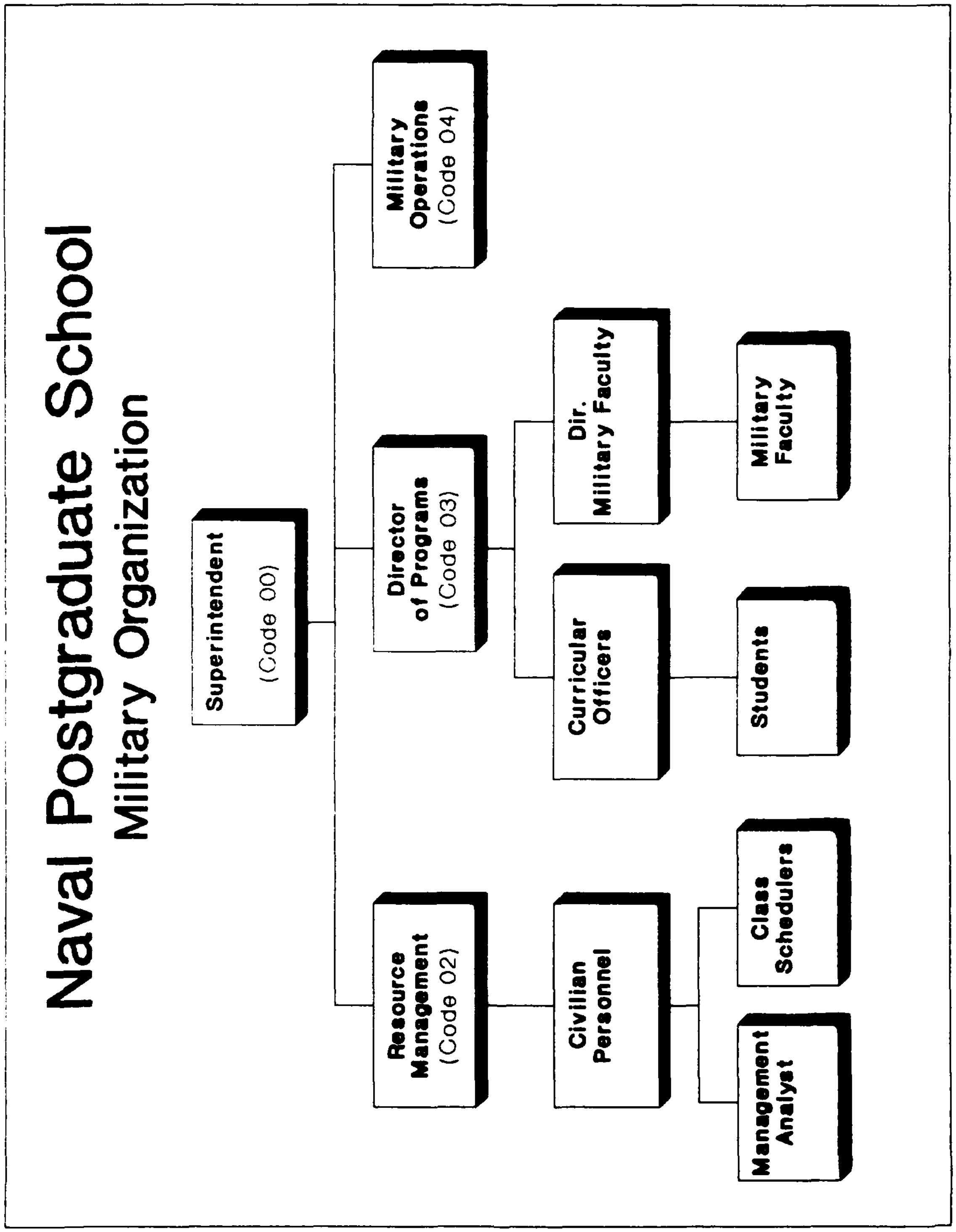

Figure 1.2 Naval Postgraduate School Military Organization (1992)

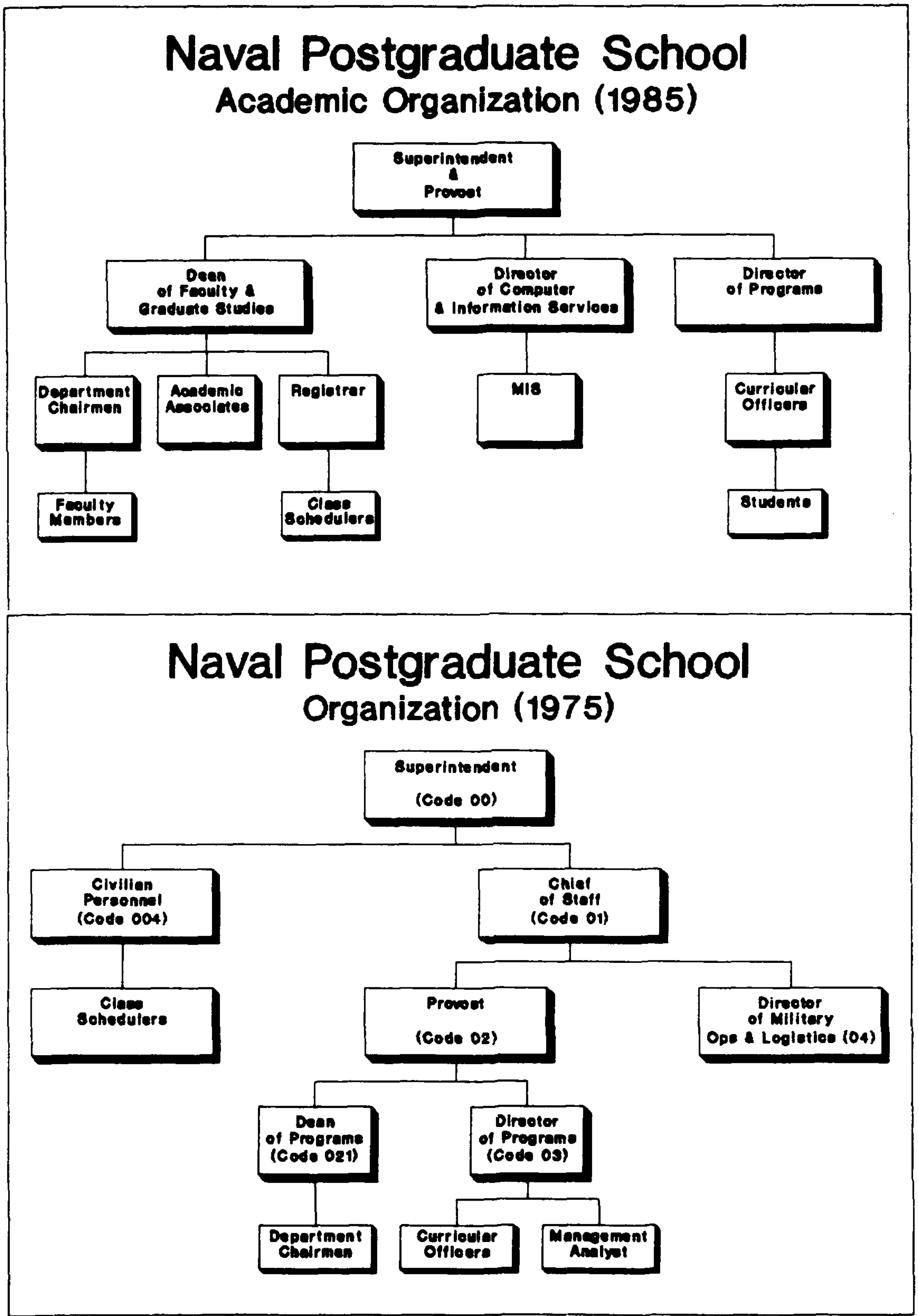

Figure 1.3 Naval Postgraduate School
Past Organizations

1. **Forecasting**

Up to a year or more in advance, departmental schedulers and the Management Analyst forecast probable quarterly student course demands and instructor workloads necessary to meet these demands. A Tentative Course Schedule is produced indicating which courses are expected to be taught by each academic departments during each quarter.

2. **Pre-Scheduling**

Pre-Scheduling is a quarterly process. Curricular Officers, via the Management Analyst, give departmental schedulers information about which courses their students are requesting for that quarter. Departments then determine which courses will actually be taught that quarter. If there are requested courses that will not be taught, students replace these with ones that will be. After receiving this updated information, departments divide courses that are too large into segments and assign instructors to teach each course.

3. **Scheduling**

Pre-Scheduling information is given to the Class Schedulers, who use it to construct a Master Instruction Schedule and individual schedules for students, instructors and classrooms. Schedules for the upcoming quarter are then distributed to applicable offices and individuals.

4. Post-Scheduling

After the final schedule is constructed, and all through the scheduled quarter, changes may be made to student, instructor or room schedules. Student schedule changes are approved by their Curricular Officer and Academic Associate. Instructor schedule changes to a course's room or time periods are coordinated by the Class Schedulers and the changes are registered and maintained by them. [Ref.4]

C. THESIS RATIONALE AND ORGANIZATION

1. Present Situation

Course scheduling for all students, instructors and rooms is performed manually by Class Schedulers, using pencils and 5" x 8" cards, much as it has always been done at NPS. Using inputs from Curricular Officers and departments, two Class Schedulers spend the quarter preceding the one being scheduled constructing a workable course schedule for some 1875 students and 270 instructors (1992 figures). [Ref.4]

Class Schedulers construct the schedules using virtually the same time-proven heuristics, self-established guidelines and experienced decision-making techniques Class Schedulers have developed and used over the past 25 years (compare early Steps in Scheduling sheet in Appendix B with present-day scheduling guidelines in Appendix C) [Ref.5]. All cross-checks for conflicting times and rooms, and all changes in both the developing and final schedules are made manually.

A self-devised system of color coding and symbology help Class Schedulers distinguish types of schedules, alert them to potential difficulties, and indicate the status of scheduling progress.

Each course's schedule is written on the applicable cards representing approximately 1100 Student Course Groups[1] and the cards of its assigned instructor(s) and classroom(s). Any corrections to this trial schedule are erased on every associated card and a new schedule written in. A final set of Student Schedule Cards is photocopied three times, Instructor Schedule Cards twice and Classroom Schedule Cards once, and their copies are distributed throughout the campus.

After the final schedule is written, and all during the scheduled quarter, Class Schedulers still have to make a significant number of changes and additions, e.g., changes to course rooms or times and finding rooms for unanticipated meetings, which are written onto the Classroom Schedule Cards. [Ref.4]

2. Thesis Intent

The intent of this thesis research is to propose and describe ways to assist NPS Class Schedulers and, secondarily, other parties involved in the NPS scheduling process, in

---

[1] A separate Student Schedule Card is produced for each group of students in each curriculum that are requesting the identical set of courses in the same quarter, referred to in this study as a Student Course Group. For 1500-2000 students, this now averages about 1100 cards.

constructing the NPS schedule more easily and efficiently than can be done by the current, primarily manual, methods. Several attempts have been made over the past 35+ years to achieve this aim by automating either part or all of the scheduling process. To date, all attempts to totally automate the NPS scheduling process have failed.[2] However, several attempts to automate parts of the scheduling process have been successfully implemented into the current process. This thesis will show how a partly automated, partly unautomated decision support system, the proposed Naval Postgraduate School Scheduling Support System (NPS^4), can

- give Class Schedulers flexibility to decide on how much automation they wish to apply to the scheduling process,
- relieve them of the minimally-productive and time-consuming labor of having to manually construct purely repetitive aspects of the schedule,
- possibly free valuable weeks that could be used by the parties involved to increase the effectiveness of the Pre-Scheduling phase,
- eliminate the need for voluminous amounts of paper schedule cards and photocopies of cards, and possibly reduce some present requirements for computer printouts, and
- maintain the human element required to construct a schedule of such complexity and continue to allow the freedoms of choice enjoyed in the present scheduling process.

---

2 That is, with the possible exception of the NPSS stochastic model developed by Professor Erickson proposed for use in the Naval Postgraduate School Scheduling Support System (NPS^4). See Chapter IV Section E for details.

It is important to note the last aim of this research. There is no intent to replace the NPS Class Schedulers with a computer program. On the contrary, one of the results of this study reveals that NPS Class Schedulers are an indispensable part of the scheduling process and the primary reason for choosing a decision support system over other possible automation tools. Indeed, there are parts of the process that would be undesirable to automate. Additionally, the very nature of the problem precludes a 100% solution to the scheduling problem by any automated means.

3. Thesis Organization

To achieve the aim of assisting NPS Class Schedulers in constructing the NPS schedule, this thesis

- examines every detail of the present scheduling process, including the role played by each party, i.e., Class Schedulers, Curricular Officers, the Management Analyst and departments in the integrated scheduling process,
- proposes and recommends ways to develop a decision support system, the Naval Postgraduate School Scheduling Support System (NPS^4), to assist NPS Class Schedulers,
- discusses alternative approaches to the NPS scheduling problem, both automated and unautomated, examining the utility and cost of each,
- describes the challenges and concerns facing effective implementation of the NPS^4 concept,
- describes future recommended approaches to developing NPS^4 beyond that able to be completed in this thesis, and
- discusses conclusions and lessons learned by this thesis' authors in having undertaken this research.

II. DEVELOPMENT OF THE NPS SCHEDULING PROCESS

A. HISTORY OF NPS SCHEDULING

1. Pre-1945

In 1909, the Secretary of the Navy established a School of Marine Engineering at the Naval Academy, Annapolis, Maryland. By the 1920s, a General Line and other schools were established and interservice and international officers accepted into their programs. In 1945, the Naval Postgraduate School was made a fully accredited, degree-granting graduate institution by act of Congress [Ref.1:p.322-3]. Scheduling at that time was performed along with Registrar activities from the Executive Officer's office [Ref.6:p.2].

2. Part-Time Scheduling

In 1951, NPS moved to its present location in Monterey, California. At that time, there were 370 students, 65 civilian faculty members and 50 Navy staff officers and civilian administrative and service personnel [Ref.7:p.1]. The three schools that comprised NPS, the Engineering School, Management School and the General Line & Naval Science School, all performed their own scheduling through individual School Scheduling Officers (SSO) [Ref.8:p.1].

In 1958, due to increasing cross-utilization of faculty members between the three schools and an increasing

student and faculty population, NPS created a new position of Central School Scheduling Officer (CSSO), also called the Schedule Coordinator, to construct an integrated course schedule. The new CSSO worked in the office of the Registrar under the direction of the Academic Dean [Ref.8:p.1] and [Ref.9]. The initial relationships between the CSSO and SSOs, and procedures needed to construct an integrated school-wide schedule were established in PGS Instruction 5010.3 (old and new versions are found in Appendices B and C) [Ref.8:p.2] and [Ref.9]. The part-time position of CSSO was filled by a mathematics professor familiar with computers with the assistance of a full-time clerk [Ref.10].

The CSSO established many of the guidelines that Class Schedulers and others involved in the NPS scheduling process follow today, including changing the daily schedule to the familiar 0800-1700 schedule used today [Ref.11].

Other scheduling policies established during this period were guidelines on the number of students per course segment [Ref.12], establishing a final examination week [Ref.13] and the precedence of instructors requesting time and room preferences for the courses they were assigned to teach [Ref.14]. Although attempts have been made to curtail this practice [Ref.15], it remains an unofficial part of the NPS scheduling process to the present day.

3. Full-Time Scheduling

As the number of courses offered and student enrollment increased, the CSSO, Professor Horace Ayres, found that more time was being devoted to constructing the schedule and less time was available to perform primary faculty duties [Ref.10]. The part-time CSSO was replaced by two full-time civilian Class Schedulers in about 1965. One of the Class Schedulers, Jackie Olsen, remained in the position from 1965 through 1983. Her assistant, Mary Horn, took over scheduling responsibilities in 1984, after a four year apprenticeship from 1979 to 1983. She remained head scheduler until 1992, when her assistant of five years, Edith Phillips, took over primary scheduling duties. She too has an assistant, Lisa Quideleg, who started scheduling in the Fall quarter of 1991. The details of constructing the course schedule at NPS have been passed down from one scheduler to the next and have essentially resided in the minds of only four primary persons and their assistants over the course of the last 30+ years. [Ref.4]

4. Scheduling by Student Demand

Prior to 1973, the courses that students attended each quarter were determined mainly by the Curricular Officer's assessment of student needs to meet curriculum requirements, with little or no student input. Course demands were determined independently by the nine Curricular Officers at

that time, who sponsored some 20 curricular programs [Ref.16]. There was no integrated school-wide forecasting process as there is today. [Ref.2]

In 1973, an NPS Management Analyst, Mike Troian (present Code 611, initially the Administrative Assistant for Programs, Code 0301, then the Special Assistant to the Dean of Academic Planning and later the assistant to the Dean of Academic Organization, Code 0144A), incorporated the concept of Management by Objective[3] into the NPS scheduling process [Ref.17:p.241]. Using methods adopted from the Program Planning Budgeting System (PPBS) used in state-wide planning processes [Ref.2], the Management Analyst divided the scheduling process into three phases of execution, Forecasting, Pre-Scheduling and Scheduling. A fourth phase, Post-Scheduling, has been identified and described in this research.

As part of the Forecasting phase, a formal school-wide system was initiated to predict near-future student attendance levels and faculty teaching demands and consequently to predict the required budget. Except for changes in procedures due to automation of parts of the process, this is essentially the same system that exists today [Ref.2]. As part of the

[3] Management by Objective (MBO) is a managerial technique credited to General Motors that involves goal setting and planning for managers and work groups. It is intended to give members a voice in the process and clarify for them what is expected to be accomplished in a specified time period.

Forecasting phase, matrices of required courses for each quarter of each curriculum were established so students could predict course requirements and track their progress throughout their curricular program (see Appendix C for an example). Forecasters could also use the course matrices to predict course demands and associated faculty workloads. Students were now able to take an active part in scheduling by working with their Curricular Officers to ensure courses forecast for them were adequate to meet their curricular program requirements and by selecting which courses they would take as electives.

As part of the Pre-Scheduling phase, Curricular Officers, Department Chairmen and Class Schedulers were given a Pre-Scheduling Activities Memorandum by the Registrar (see Appendix C) that detailed what actions were required and when actions and reports were due to collect information the Class Schedulers would use in the Scheduling phase to construct quarterly schedules.

5. Standardization of Abbreviations

As often happens when information is automated, abbreviations are created for key elements to reduce the requisite amount of memory space required to represent them. These transformations of names into abbreviations have taken place gradually over the course of the development of NPS scheduling as some of the process has been automated.

For example, EC4370 refers to the 4000 level course offered by the Department of Electrical and Computer Engineering called Mathematical Models and Simulation for Control Systems [Ref.1:p.189]. Curriculum sections and Student Course Groups are abbreviated, e.g., PL13 refers to the group of students who began taking the courses required for the Computer Systems Management curriculum in the 3rd quarter of Academic Year (AY) 1991. PL1307, a subsection of the PL13, refers to the student or group of students in that curriculum section who have been assigned an identical set of courses during that quarter, i.e., a Student Course Group. The curriculum itself, Computer Systems Management, is also recognized by abbreviations in the form of letter or number codes, i.e, 367 or PL. [Ref.18]

To avoid ambiguity and automated data redundancies, abbreviations are standardized. In 1970, as the Forecast Program began to take root in the scheduling process, an NPS instruction [Ref.18] was issued to standardize designations used for curriculum sections. Later, other abbreviations were created and standardized, e.g., the Administrative Sciences Department could be recognized by as Code 54 or Code AS, and AS/Dk referred to faculty member Professor (Prof.) Dan Dolk, who taught in the Administrative (Admin.) Sciences Department (Dept.). Like the codes used for the Management Analyst, the Class Schedulers and Curricular Officers also have codes. [Ref.1:p.113]

B. PREVIOUS AUTOMATION ATTEMPTS

Attempts to automate the NPS scheduling process have met with varied success. Most attempts in the 1950s-1960s were too cumbersome (due in part to the limited languages and tools available then). However, attempts in the 1970s-1980s to automate parts of the NPS scheduling process were successfully implemented and are used today. The Forecasting and Pre-scheduling phases are almost entirely automated, whereas the Scheduling and Post-Scheduling phases remain almost entirely unautomated.

1. Early Automation Efforts

a. Engineering School Program

In the mid-1950s, the NPS Engineering School developed a semi-automatic scheduling system that ran on an early mainframe with 80 character punched card input (see Appendix B for an example of the program output). It required the supervision of a computer-literate mathematician and was produced at a considerable cost in time and effort on the part of several professors. [Ref.8:p.1] and [Ref.10]

b. Heuristic Academic Master Scheduler

In 1966, a program written in the SCRAP assembly language called the Heuristic Academic Master Scheduler (HAMS) was written to fully automate the NPS scheduling process. It was capable of scheduling 90-95% of all required courses, leaving 5-10% that to be manually resolved. The program was

never implemented successfully due to the difficulty of maintaining the assembly language program and because the schedule it produced used almost all the rooms and time periods, so the last 5-10% of unscheduled courses could not be added without rewriting much of the original. Also a major portion of the program included scheduling student aviators for flights, which was no longer relevant after the flying program was eliminated in the late 1960s. [Ref.19:p.14]

2. Successful Automation Efforts

Beginning in the late 1960s, parts of the scheduling process were successfully automated. These early programs involved database management of student and course data and programs that processed this data into information useful to forecasters.

a. ARISE Application

Written at NPS in the late 1960s, ARISE was the principal program used to store and manipulate student data useful to the Registrar. ARISE had an indexed sequential file organization, where file records are written to a secondary storage device in sequential order, but can be accessed directly using key indexes. ARISE was later replaced by a series of FOCUS language programs from 1985-1987, but a residual of this program can be found in the student "hash" number index in present FOCUS files (see Section B2e). [Ref.2] and [Ref.20]

b. Forecast Program

In 1969, two NPS students created a computer program in the COBOL language that was designed to aid the Dean of Programs in forecasting future faculty teaching requirements [Ref.21]. It calculated faculty demand based on student-course pairing information supplied by Curricular Officers, who submitted Forecast Schedule forms containing the courses assigned to each Student Course Group (see Appendix B for an example). This information was transferred manually to punched cards by an assistant to the Management Analyst. The punched cards were then used as input by the Forecast Program. This program generated two tailored reports called the Curricula Officers Report and the Academic Chairman Report, the names of which, if not their exact format, are retained in reports used in the scheduling process today (1992).

Though intended to be a tool for forecasting, the Forecast Program was used from 1970-1973 as the primary method of compiling scheduling information for what would become the Pre-Scheduling phase of the NPS scheduling process. The program was expanded in 1970-1971 to include three other reports that analyzed, backed up and summarized the information. In 1973, it was rewritten to act as a true forecasting program, where it receives information from a new Scheduling Program and uses it to project ahead course and instructor loads for as many quarters as required. [Ref.2]

c. Scheduling Program

In 1973, a program called the Scheduling Program was written in the PL1 language to perform the information compiling function the old Forecast Program had, but using the newly formatted Academic Program cards (see Appendix B) [Ref.22]. The Forecasting and Pre-scheduling phases were formally differentiated. The program also adopted the Curricular Officer Report and the Department Chairman Report from the Forecast Program (see Appendix C). [Ref.2]

d. Schedule Card Program

In 1974, a PL1 language program called the Schedule Card Program was successfully implemented into the NPS scheduling process. It produced one Student Schedule Card for each Student Course Group from student-course pairing information extracted from the Scheduling Program (see Appendix C). In 1974, it automatically created about 700 cards for each quarter, each of which had previously been hand-written and then key-punched into the mainframe computer. Still in use today (1992), the same program creates Student Schedule Cards for nearly 1100 Student Course Groups. However, approximately 270 Instructor Schedule Cards and over 100 Room Schedule Cards are still created by hand each quarter. [Ref.16] and [Ref.7]

e. FOCUS Applications

In 1985-1987, a series of database management programs were written in FOCUS (a 4th generation database language) and implemented into the NPS scheduling process. They successfully automated most parts of the Pre-Scheduling phase by allowing Curricular Officers to enter student-course pairing data directly into the mainframe computer via a terminal, thereby eliminating the need for manual Academic Program cards. [Ref.2] and [Ref.20]

In 1988, FOCUS was also applied to report generating aspects of the Master Instruction Schedule, the end-product constructed by the Class Schedulers in the Scheduling phase (see Appendices B and C). Class Schedulers could enter the final schedule onto a mainframe terminal in their office and it was printed automatically. Before 1988, the Master Instruction Schedule had to be typed manually by the Class Schedulers. [Ref.4]

f. Heuristic Model Programs

In 1985, another NPS student, Dietmar Fiegas, attempted to automate parts of the scheduling process as part of a thesis study using a heuristic approach. Fiegas wrote one program in FOCUS to capture the constraints made on courses through a questionnaire to instructors assigned to each course [Ref.23:p.27,124-133]. He also wrote a partly interactive program in PL1 called Final PLC that successfully

produced a viable final examination schedule, with no remaining conflicts, using real data from the Winter quarter of Academic Year (AY) 1985 [Ref.23:p.33-55,90-123]. In addition, he wrote a program based on an Integer Linear Programming (ILP)[4] optimization approach that could schedule a single course, though he realized that the NPS scheduling system was too large to apply this technique to the entire process [Ref.23:p.70-77,135-136]. Although none of his work has been applied so far, several ideas have merit and are discussed further in Chapters IV and V. [Ref.23]

g. On-Line Course Catalog

In 1988, another Management Analyst, Hans Dolman, wrote a FOCUS program that automated a looseleaf course catalog created by Mike Troian so it could be made accessible to students and others using the NPS mainframe. Unlike the published course catalog (see Reference 1), which was often out-of-date by the time it got to print, the on-line catalog could be continuously updated as course information changed. It is presently maintained by Management Analyst Mike Troian and is used as the standard source of course information for the NPS scheduling process. [Ref.2] and [Ref.4]

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[4] Integer Linear Programming (ILP) is a mathematical approach to decision-making used in Operations Analysis/ Management Science which involves constructing an objective equation and constraint equations from a group of linear variables and solving for an optimum solution.

C. PRESENT AUTOMATION IN NPS SCHEDULING

Throughout the course of development of the NPS scheduling process, there have been numerous attempts to automate all or portions of it. Several attempts have been successfully adopted in an effort to help reduce the amount of labor required to produce each quarterly schedule, to make data entry more efficient, to more easily manipulate large volumes of data entries, and to efficiently forecast course demands and faculty workloads.

Today, nearly all of the Forecasting phase of scheduling has been automated by use of the Forecast Program. During the Pre-Scheduling phase, much of the data entry and manipulation functions have been automated by use of the FOCUS program system. The Schedule Program creates automated outputs from this system, which include the Curricular Officer Report and the Department Chairman Report, as does the Schedule Card Program, which creates Student Course Group Schedule Cards.

These applications have allowed easy access to student and course information, resulting in conveniences such as the On-Line Course Catalog and reports described in the next chapter. As Chapter III will point out, other automated applications have simplified communications between involved parties and made their duties easier and more efficient. However, with the sole exception of an automated report generator for the final schedule, automated applications have not been created for either the Scheduling or Post-Scheduling phases.

Chapter III explores in detail how the NPS scheduling process is presently conducted. Chapter IV examines how the NPS scheduling process could be conducted more efficiently with the aid of a decision support system, the proposed Naval Postgraduate School Scheduling Support System, NPS^4.

III. THE PRESENT NPS SCHEDULING PROCESS

This chapter examines in detail how the present NPS scheduling process constructs schedules for each quarter. The process can be divided into two intertwining views:

- The visible process - directive documents, intermediary products such as files and reports, the flow of these intermediary files and reports from one party to the others, and final products such as schedules.

- The invisible process - how directives are interpreted, what data is input, how data is turned into information needed for the final products, the information reports contain and why, communications between parties, and how the actual elements of scheduling, i.e., students, courses, instructors, rooms and time periods, are combined to construct a working schedule.

The process can also be divided into four temporal phases. Though not absolutely delineated, these temporal divisions, like the visible and invisible parts of the scheduling process, have characteristics that are clearly recognizable which distinguish them from the others:

- Forecasting - the process of projecting ahead for as many quarters as required the resource requirements involved in scheduling - how many students, courses, instructors, rooms and time periods will be required for each future quarter to be scheduled.

- Pre-Scheduling - the process of collecting data and turning it into information needed to construct a schedule.

- Scheduling - the process of turning collected information into a workable schedule.

- Post-Scheduling - the process of making changes to schedules constructed in the Scheduling phase and compiling schedule data to aid in forecasting.

The visible process - the files, reports and documents that can be physically described - is discussed first so that these objects will be familiar during subsequent treatment of the subject. Following that, the activities that occur during each phase of the process are described in detail, notably the undocumented invisible steps followed to produce the visible parts of the process.

A. DESCRIPTION OF THE PROBLEM

One way to begin investigating how the present scheduling process works is to look at the process parameters, i.e., the elements involved in the process and the ranges of values they can take. What has to be scheduled? How large is the problem? What are the time constraints? Another approach is to look at the inputs to the system, the data stored in the system and the outputs from the system in the form of reports and schedules. Still another perspective is to examine instructions and guidelines directing the process. Section IIIA examines all three of these approaches.

1. Schedule Parameters

The following parameters describe the environment around which the NPS schedule is constructed:

a. The Academic Calendar

The NPS academic year starts on the Monday nearest October 1st and is divided into four quarters of 12 weeks each (Fall, Winter, Spring, Summer), with 11 weeks of instruction and one week of final examinations. There are two week breaks between Fall and Winter quarters in December and Spring and Summer quarters in June. Each academic week consists of five days (Monday-Friday) and each academic day has nine one hour periods of instruction. The academic day begins with Period #1 at 0800 and ends with the conclusion of Period #9 at 1700. The first 10 minutes of each period are intended to allow students time to travel between classes and the last 50 minutes are used for teaching the course. See the weekly layout on schedule card examples in Appendix C. [Ref.1:p.340], [Ref.4] and [Ref.23]

b. Students and Courses

Each quarter roughly 1500-2000 students, in 38 curriculums within 11 curricular programs, enroll in 250-300 courses from a total of almost 900 courses listed in the course catalog [Ref.1:p.334-9]. Some courses are divided into one or more segments to accommodate more students in a course than seating space in its classroom, and to preserve the student-instructor ratio. Figure 3.1 shows the number of students enrolled in courses, the number of courses or course segments offered and other scheduling information for each quarter of the years 1979-1992.

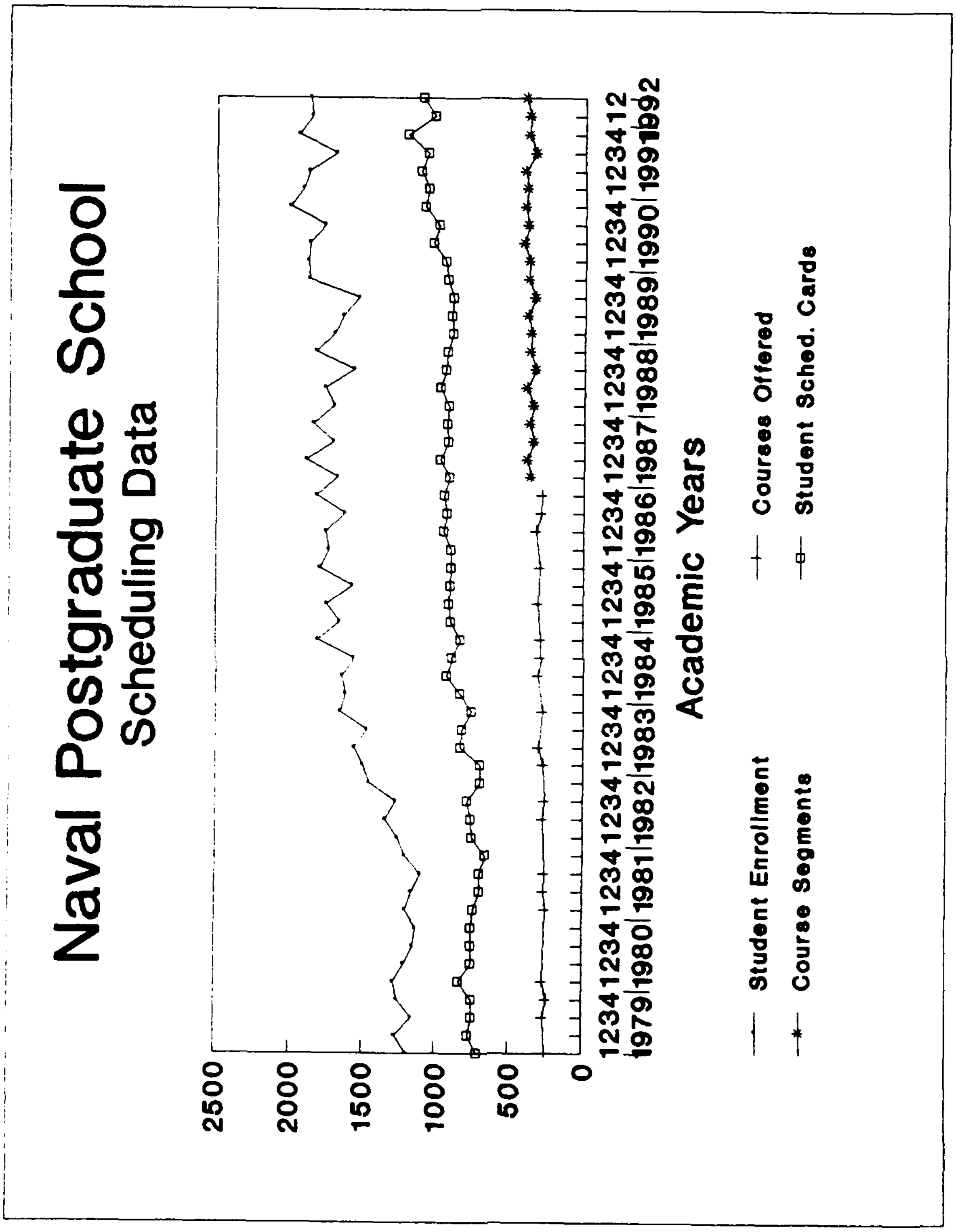

Figure 3.1 NPS Scheduling Data for 1979-1992

Students enroll in a maximum of six courses each quarter. The minimum number of courses a student must take varies, and is usually established by their Curricular Officer. A course usually includes periods of instruction, but some courses are actually time periods reserved for Curricular Officer inputs, seminars, lectures, directed study or thesis research.

Each curriculum lasts from six to nine quarters. Consequently, approximately 200 new students enter curricula and 200 students graduate each quarter after studying at NPS for 1.5-2.5 years. See Student Enrollment Summary in Appendix C. [Ref.1]

2. Schedule Elements

The principal elements of any school schedule are students, courses, instructors, classrooms and time periods for instruction. These elements are related to each other in defined ways, i.e., students take courses, which are taught by instructors, in classrooms, during scheduled time periods. Constructing the NPS course schedule is essentially a matter of solving a number of frequently interconnecting, and sometimes conflicting, pairing problems involving these elements (e.g., student-course, course-instructor).

Not all pairings, or relationships, between these scheduling elements are relevant to all phases of the NPS scheduling process, but almost all are encountered somewhere in the process in the various files and reports.

3. Official Files, Reports and Documents

Many of the computer files, reports and documents used to construct NPS schedules are officially directed by Instructions, with responsibilities for their creation shared by several parties. There are also "unofficial" computer files, reports and documents internally generated by these parties that act as intermediaries between official files and reports, as memory aids or instructions on how to produce the official files and reports, or communications between parties regarding the construction of official files and reports. Officially directed files and reports are described in this section, along with the documents that direct them. Unofficial files and reports are described in Section A4.

a. Mainframe Files

As described in Chapter II, portions of the scheduling process have been automated. The principal medium used to date for official scheduling has been the NPS mainframe computer. The mainframe computer has changed several times throughout the 40 years of NPS scheduling, as have the computer languages used to produce the scheduling application programs. Original files have had to be updated as a result of changes to the mainframe or languages. Remnants of these changes can sometimes be found in the fields or the structures of current files. Examples can be found in the Curricular Officer Database and Schedule Card Program, the structures of which are examined in Chapter IV.

Most scheduling programs access one of two separate databases containing scheduling information. These two official databases, one used by Curricular Officers and the Management Analyst, and one by the Registrar and Class Schedulers, are both presently written in FOCUS, but originated separately in PL1 and ARISE, respectively. A plan by the NPS MIS Department to integrate them into a single Integrated Systems Plan (ISP) is in the planning stages. [Ref.4], [Ref.20] and [Ref.25]

<u>(1) Curricular Officer Database.</u> Curricular Officers enter student-related pairing data into a mainframe database referred to in this thesis as the Curricular Officer Database and the Curricular Officer's FOCUS System in the principal scheduling directive [Ref.23]. The primary scheduling file within this database is the SECT file. It contains much of the information required by the Scheduling Program to create the Curricular Officer Report, Department Chairman Report and Student Schedule Cards, and is used as a base for projections by the Forecast Program. It also contains most of the information needed by the NPS Scheduler (NPSS) program, the primary computer model of the proposed Naval Postgraduate School Scheduling Support System (NPS^4) described in Chapter IV. [Ref.2] and [Ref.26]

<u>(2) Registrar Database.</u> The Registrar Database contains both academic and personal information on students enrolled at the Naval Postgraduate School. Although

much of it is peripheral to the scheduling process, it contains some redundant information contained in the Curricular Officer Database that is extracted for reports in several phases of the scheduling process.

b. Scheduling Reports

(1) Curricular Officer Report. The Curricular Officer Report is a product of the Scheduling Program. It is a computer report compiled and printed out by the Management Analyst, containing student course request information extracted from the SECT file in the Curricular Officer Database. Appendices B and C contain representations of historical and present report examples.

(2) Department Chairman Report. The Department Chairman Report is another product of the Scheduling Program. It is also a report compiled and printed out by the Management Analyst from information extracted from the SECT file. It contains course scheduling information, some of which is added manually by departments during the Scheduling phase. See Appendix C for a representation of the present report.

(3) Schedule Cards. Five different types of Schedule Cards are created in the NPS scheduling process: Student Course Group Schedule Cards or Student Schedule Cards for short, Instructor Schedule Cards, Regular Classroom Schedule Cards, Regular Laboratory Schedule Cards, and Final Exam Schedule Cards.

Student Schedule Cards are a report created by the Schedule Card Program and printed by the Management Analyst. One card is created for each Student Course Group. Student Schedule Cards are a set of pre-formatted, white 5" x 8" cards on a continuous, fanfold, tractor-fed sheet with perforated edges separating them. The pre-printed format, common to all schedule cards, contains a weekly schedule layout. Scheduling information is printed in appropriate areas of the card by the Schedule Card Program; information on the other cards is typed manually by the Class Schedulers. The Schedule Card Program prints student and curriculum information on each card to identify the Student Course Group it represents. The program also prints student-course pairing information extracted from the SECT file. During the Scheduling phase, course schedule information is written on the cards by the Class Schedulers to construct a final schedule for each Student Course Group. See Appendices B and C for historical and current examples of this report.

Instructor Schedule Cards are a set of yellow, individual, pre-formatted 5" x 8" cards. One card is created for each faculty member teaching that quarter, with identifying department, faculty, course and schedule information typed on the cards by the Class Schedulers. During the Scheduling phase, the Class Schedulers add course schedule information to the cards to produce individual schedules for each instructor. See Appendix C for an example.

Regular Classroom Schedule Cards are a set of orange, individual, pre-formatted 5" x 8" cards. One card is created for each classroom, with identifying classroom and schedule information typed on the cards by the Class Schedulers. During the Scheduling phase, Class Schedulers add course schedule information on the cards to construct the individual schedule for each classroom during the regular 11 week instruction period. See Appendix C for an example.

Regular Laboratory Schedule Cards are a set of green, individual, pre-formatted 5" x 8" cards. One card is created for each laboratory, with identifying department and schedule information typed on the cards by the Class Schedulers. During the Scheduling phase, the Class Schedulers write additional department and schedule information, as well as some course and faculty information on the cards to produce the final individual schedule for each laboratory during the regular 11 week instruction period. See Appendix C for an example.

Final Exam Schedule Cards are a set of green, individual, pre-formatted 5" x 8" cards. One card is created for each classroom in which a final examination is scheduled with the same identifying information typed on it as the Regular Classroom Schedule Cards. They are similar to the Regular Classroom Schedule Cards, except that they are green and only the classrooms in which final exams have been scheduled are in this set. However, during the Final

Examination part of the Scheduling phase, the Class Schedulers write additional department and schedule information, as well as some course and faculty information to produce the final examination schedule for each course segment scheduled for that room. See Appendix C for an example.

(4) Master Instruction Schedule. In addition to individualized schedule cards, the Master Instruction Schedule is the primary end-product of the NPS scheduling process. It is a report generated by the mainframe from schedule card information entered by the Class Schedulers. See Appendices B and C for historical and current examples of this report.

(5) Tentative Course Schedule. The Tentative Course Schedule is a report compiling course information forecast from each NPS academic department entered by the Management Analyst. The computer report is produced each year as a booklet of courses expected to be offered each quarter. See Appendix C for a representation of this report. [Ref.23]

(6) Summary Listing/Course Offerings. The Summary Listing, or Course Offerings, is a typed report submitted by each academic department, specifying which of its courses will be offered and which will not be offered during the scheduled quarter. There is no standardized format and the style of the report varies from department to department (see Appendix C for examples). Since it is a typed report and not a computer printout, it is not derived directly from either of

the mainframe databases mentioned. However, departments may maintain their own computerized databases on either personal computers, the mainframe computer or on paper records, and this report may be constructed from this information.

(7) Exception Listing. The Exception Listing is a computer report compiled and printed out by the Management Analyst. Its purpose is to perform a quality check on Curricular Officer inputs, pointing out possible errors in entries, i.e., differences between entries and course information in the On-Line Course Catalog. See Appendix C.

c. Scheduling Documents

(1) NAVPGSCOL Instruction 5010.3 series. The latest version of this instruction, entitled Class Scheduling Procedures, is at least the ninth since 1958. The enclosure to 1976's version 5010.3F was changed substantially enough to warrant renumbering the instruction, beginning with 5010.3A again, dated 19 July 1991. The current version, 5010.3B, dated 11 October 1991, directs additional minor process changes (see Appendix C). [Ref.8], [Ref.23] and [Ref.27]

This instruction is the primary directive for the NPS scheduling process, assigning responsibilities of all parties and sets some schedule parameters and constraints. A Quarterly Calendar of Procedures for the Class Scheduling Operation is an enclosure that directs the actions of Curricular Officers, Department Chairmen, the Management Analyst and Class Schedulers through each of the 12 weeks of

the scheduling process, including a directive to create most of the official scheduling reports. [Ref.23]

(2) NPS Instruction 1520.11/19 series. The latest version of this instruction is entitled Assignment of Academic Section Designators, NPS Instruction 1520.19 CH-1, dated 21 October 1983. It, like the original Procedures for Assignment of Section Designators dated 28 January 1969, directs the assignment and standardization of curriculum section designators (e.g., PL11) and the designations for Student Course Groups (e.g., PL1107). See Appendices B and C for representations. [Ref.18] and [Ref.28]

(3) Other Scheduling Directives. Other directives or guidance documents that have influenced the scheduling procedure have taken the form of memoranda from the Provost and other administrators. Some are referenced in the description of the development of the NPS scheduling process in Chapter II. A more recent example is a memorandum from the Provost dated 16 January 1990 affected the Class Schedulers' chain of command and verified or changed department, academic group and faculty codes (see Appendix B). [Ref.29]

4. Internally Generated Reports and Documents

Besides the files and reports created by directive, there are other files, reports and documents internally generated by individual parties involved in the scheduling process to aid them in performing their duties. For example,

memoranda may be written to instruct others on how best enter information on a report they need from another party. Records may be made to collect or organize the data needed to create an official computer file or report. Alhough these reports and documents may be used over the course of one or more phases of the scheduling process, they are presented here in the scheduling phase in which they originate. Appendix C contains examples or representations of most of these reports or documents.

Only physical reports and documents that have a direct bearing on the scheduling process are presented here. Computer files, records and databases kept by each party vary too greatly between parties to warrant covering them in the scope of this research.

a. Forecasting Phase

The reports and documents generated during this phase of scheduling are created to assist in determining course and instructor loads for each upcoming quarter.

(1) Curriculum Course Matrix. The Curriculum Course Matrix is a document created by the Curricular Officer and the Academic Associate for each curriculum for which they are responsible. It is a matrix of courses that are required to be taken by the students in that curriculum showing the quarters that they would normally take them. Most of the courses are specified and are required to complete the

curriculum. Other courses are not specified, but are left to the student's choice as electives. All Curriculum Course Matrices may be found in the NPS Course Catalog [Ref.1], where they are referred to as Typical Courses of Study and elective courses as Curriculum Options. [Ref.1] and [Ref.30]

(2) Option/Emphasis Area Declaration. This form-style document is used by Curricular Officers to solicit student elective course selections. Usually students take only required courses during the first few quarters of their curriculum. Later they select an optional or emphasis area of study that complements the curriculum. This form is filled in by students and the information is entered into the Curricular Officer Database by the Curricular Officer.

(3) Option/Emphasis Area Course Selections. This document is created by the Curricular Officer and Academic Associate responsible for each curriculum. It contains elective courses students may select in their optional or emphasis area of study. Some are courses required for the chosen area of study and others that may be taken as the student's course load and interest permit.

(4) Student Input Sheet. The Student Input Sheet is a report created for each calendar year by the Management Analyst from quarterly information obtained from the Office of Admissions concerning the number of students projected to start each curriculum, based on quotas established by the

Bureau of Naval Personnel. For each curriculum, it shows how many students are expected from each U.S. armed service, how many are expected to be international or civilian students and whether students starting curricula need a "refresher" quarter before entering their chosen curriculum (see Section B1a for an explanation).

(5) Course Projection. The Course Projection is a report created by each department every academic year. It shows the quarters during which department courses have been forecast to be taught.

(6) Alpha Recall Listing. The Alpha Recall Listing is a report derived from the Registrar Database available for Curricular Officers to view on screen or print out. It contains professional and personal data on the students in the Curricular Officer's curricular program, including student names, addresses, phone numbers, military rank, service, country and curriculum information.

b. Pre-Scheduling Phase

The reports and documents generated during this phase of scheduling are created to direct the timing of official reports, to assist in producing official reports and to allow the Class Schedulers to examine Pre-Scheduling information early to plan for the Scheduling phase.

(1) Pre-Scheduling Memorandum. This document is created by the Office of Registration and Scheduling a quarter in advance of each quarter to be scheduled. It sets guidelines for when scheduling actions are to take place, when official reports are due, who is responsible for these actions and reports, and where the reports are to be delivered. It supplements the primary scheduling directive, NAVPGSCOL Instruction 5010.3B, by detailing dates and times at which actions will occur, by giving more specific directions and listing persons to contact to resolve procedure problems.

(2) Department Chairman Report Guidelines. This document is produced and distributed by the Class Schedulers. Entitled "Submission of [quarter name] Quarter AY [year] Teaching Worksheets", it gives specific instructions and examples for how the Class Schedulers would like departments to fill in the third iteration of their Department Chairman Reports (see Section D1). It specifically gives guidance on how to submit course requirements for times and rooms.

(3) E-Z Class Demand Listing. The Class Schedulers print out this report from the Register Database each quarter. It gives forecast information on the courses likely to be offered by each department and the number of students expected to attend each course.

(4) On-Line Course Catalog. The On-Line Course Catalog is a database maintained by the Management Analyst, who uses it to update a description of all possible courses that each department may offer. Available to anyone with access to the mainframe computer, it contains course numbers, names, credits, a description of the expected course content, and other useful information about the course. It is used as the standard for NPS course information.

c. Scheduling Phase

The reports and documents generated during this phase of scheduling are created to direct the timing of official reports, to assist in creating official reports and to aid the Class Scheduler in selecting time periods and rooms for courses during the Scheduling phase.

(1) Dates for Scheduling Operation. This document is created by the Class Scheduler each quarter to direct scheduling activities for the Scheduling phase within the Class Schedulers' office. Much like the Pre-Scheduling Memorandum, it gives specific dates that materials and actions are due to and from the Class Schedulers.

(2) Student Schedule Cards Color Chart. This permanent document is created by the Class Scheduler to show how the Student Schedule Cards are marked by them when they are received from the Management Analyst. The color coding is

used for the Class Schedulers to be able to distinguish at a glance to which curriculum a card belongs.

(3) Guidelines for Setting Priorities. The Guidelines for Setting Priorities document is created by the Class Schedulers. It gives guidelines on the order by which courses with certain characteristics, e.g., those with three hour labs or those that have time or room requirements, should be scheduled based on scheduling experience evolved over the past 25+ years. The guidelines are intended only to give Class Schedulers some direction to follow to minimize course time conflicts encountered and the associated time and labor required to resolve the conflicts.

(4) Guidelines for Scheduling. This document is another guideline developed by Class Schedulers that provides specific directions on how to handle Student Schedule Cards when they are received from the Management Analyst. It is written as a reminder of the initial steps required for the Scheduling phase.

(5) Semi-Permanent Requirements Sheets. This is a group of documents created by the Class Schedulers that show semi-permanent meetings, seminars, conferences, courses or type of courses that have set time periods or rooms. The documents specify the event, its participants, and scheduling constraints inherent in the event in terms of personnel, rooms or times the event will occur. Examples range from meetings

of the Academic and Faculty Councils to courses requiring classrooms in which classified material may be taught.

(6) Scheduling Worksheet. The Scheduling Worksheet is a pad of sheets resembling a blank schedule card. It is used by the Class Schedulers to test possible course schedules for conflicting times.

(7) Master Schedule Instructions. The Master Schedule Instructions document is created by the Class Schedulers as a reminder of how data is to be enterd into the mainframe to generate the Master Instruction Schedule.

(8) Professor Listing. A report called the Professor Listing by Department is derived from the Registrar Database. Departments tell the Class Schedulers when new faculty members arrive and they both agree on a unique faculty code for them, e.g., CS/Er for Professor Erickson. The Class Schedulers give the faculty information to the Registrar's so it can be entered into the Registrar Database. The resulting Professor Listing by Department report is used to construct the addendum listing of the professors by departments attached to the Master Instruction Schedule.

d. Post-Scheduling Phase

(1) Change of Registration Form. This form-type document is used by students, Curricular Officers, Academic Associates, course instructors and the Registrar to track

changes made by students to their schedule during the scheduled quarter.

(2) Student Enrollment Summary. This report is created by the Management Analyst for each quarter of the academic year. Much like the Student Input Sheet, it breaks out students by the total number in each armed service, plus international and civilian students, but for the entire school instead of by curricula. Totals for each student category are given for those under instruction, those that have graduated, those who have been attrited or otherwise detached, students who have transferred between curricula, those that are in normal curricular programs and those that are taking a "refresher" quarter before entering their chosen curriculum.

(3) Scheduling Data Graph. This graphical report is created by the Class Schedulers for the Registrar to illustrate the total numbers of students enrolled, courses or course segments offered, Student Course Groups and classrooms available each quarter over the course of the last five years.

5. Comparison with Other Institutions

Scheduling at NPS is student-driven, unlike scheduling systems at most other schools which schedule courses based on institutional requirements. Most schools schedule courses and assign instructors first, then let students select those courses they need or want that don't have time conflicts. For example, at Stanford University, broad requirements are given

to the academic departments, each of which make separate schedules of courses from which students may choose. This has been their scheduling method for at least 30 years [Ref.6]. In contrast, students at NPS determine which courses they need or want and this information is submitted via their Curricular Officers to applicable departments responsible for offering the requested courses. Departments then assign faculty instructors to these courses and forward this information to the Class Schedulers. From this accumulated information, a schedule is developed. For further discussions on the differences between NPS and other academic institutions, see Reference 19. [Ref.2] and [Ref.4]

B. FORECASTING

The primary activity of the Forecasting phase of the NPS scheduling process is projecting ahead, for as many quarters as required, the estimated number of students at NPS during each quarter, their expected course requirements, and the resources required to meet this load, including instructors, classrooms/laboratories and supporting equipment [Ref.3]. The Forecasting phase includes any scheduling activities made prior to the beginning of the quarter before the quarter to be scheduled. In general, student and course projections are made by extending known information about present and past student enrollment and course demand trends to future quarters, accounting for any anticipated changes.

Forecasting is one of the duties of the Management Analyst, who gives forecast information to the Director of Academic Planning to plan the budget for future quarters. The primary output of this phase is a Tentative Course Schedule for the upcoming academic year, prepared by the Registrar's Office from student curricular requirements provided by Curricular Officers and from faculty availability information provided by Department Chairmen. [Ref.23]

1. Curricular Officers

The key to effective forecasting is determining the number of students expected to enter curricula, when they will arrive, and what courses they will take during each quarter they are studying at NPS. Curricular Officers, in charge of all students and their course programs, use quotas provided by the Department of the Navy to project the number of students anticipated to enter each curriculum. Information compiled from Curricular Officers is reflected on the Student Input sheet that accompanies the Pre-Scheduling Activities Memorandum. Using pre-determined Curriculum Course Matrices, Curricular Officers are able to assign blocks of courses to each curriculum section. Student-course information is entered into the Curricular Officer Database [Ref.30]. Names of individual students in each curriculum section are obtained from the Registrar Database via the Alpha Recall Listing and from monitoring outgoing electronic messages from the Director

of Admissions regarding assignments of students to curricula. If student names are unknown, the Curricular Officer constructs a "group card"[5], i.e., enters course matrix information for a student group identified only by the number of students in the group, e.g., "15 students".

During AY 1991, 923 students out of a total student population of 1875 were forecast to enter one of 38 curricula in 11 curricular programs. During the Winter quarter of AY 1992, the 38 official curricula were divided by degree (Masters or Doctorate) or other distinguishing characteristics into 47 separately designated curricula, which in turn were divided into 223 curriculum sections. Which curriculum section a student is in tells the Curricular Officer a lot about how to forecast courses for that student. For example, for the Computer Science curriculum, Code 368 or CS, which is eight quarters long, there were eight curriculum sections in the Winter quarter of AY 1992:

- CSPH is the CS Doctorate degree section.
- CS03, CS11, CS13, CS21 and CS23 are Masters degree sections which entered, or will enter, the CS curriculum every other quarter from the Fall quarter of AY 1990 to those that will enter the curriculum in the Spring quarter of AY 1992.

[5] The concept of a "group card" is a remnant of the historical NPS scheduling process before FOCUS, when Curricular Officers submitted Academic Program cards for each group of students taking the same courses. Although no longer a physical entity, the term is still used to refer to a group of students when the number of students is known, but not their names.

- The other two curriculum sections were CS01, students who which were delayed from graduating for one reason or another and who would graduate with the following section, CS03, and CS22, a fictitious curriculum section number used as a place-holder to show students who were already at NPS, but who were taking a "refresher" quarter before entering their curriculum with their classmates in section CS23 in the Spring quarter of AY 1992.

A description of all 11 curricular programs and 38 curricula offered at the Naval Postgraduate School can be found in the NPS Course Catalog [Ref.1].

a. The "Refresher" Quarter

In addition to directed curricula quotas, other factors have to be taken into account in the Forecasting phase to determine how many students will be at NPS during each future quarter. All students do not directly enter their chosen curriculum. Many curricula are quite technical and require working knowledge of advanced mathematics or physics. In addition to minimum academic prerequisites, called the Academic Profile Code, which determine whether a student is qualified to enter a particular curriculum, students may sometimes be required to take one quarter of courses that will help them get "up to speed" before entering their official Curriculum Course Matrix [Ref.1:p.18-23]. Students usually benefit from taking these courses because they may not have been in a challenging academic environment for many years and the courses serve as a buffer between their normal military routine and academic life. Whether or not a student will take

a "refresher" quarter is determined by the office of the Director of Admissions. [Ref.30]

For forecasting purposes, all students who are in this preliminary quarter are said to be in Curriculum 460, Engineering Science. This was once a legitimate curriculum and even though it no longer exists, the name is retained as a place-holding category to describe students in their "refresher" quarter. During AY 1991, it was forecast that 63% of all new students would first take courses in a "refresher" quarter before they began their curricula. In the Winter quarter of AY 1992, 13% of all students enrolled at NPS were taking courses normally offered in a "refresher" quarter (see the Student Input Sheet and the NPS Students Quarterly Enrollment by Curriculum Specialty sheet in Appendix C).

b. Curriculum Course Matrices

This matrix of courses and the quarters during which the courses would normally be taken is a representation of the ideal course schedule each student should have during each quarter they are at NPS. Departments can not always support the Curriculum Course Matrices requiring its courses. Consequently, a student may have to switch the quarters they request certain courses to take them during the quarters they are offered. Also, Curriculum Course Matrices generally contain room for elective courses selected by students using Option/Emphasis Area Declaration and Course Selection forms.

One factor students use to determine which courses to select is whether or not the courses are forecast to be offered during the quarters that are open in their Curriculum Course Matrix. This information can be obtained from the Tentative Course Schedule or each department's Course Projection sheet. Thus, forecasting information based on past scheduling trends can influence present scheduling decisions. [Ref.30]

As deviations are made from this ideal schedule that students would normally take, and as students make their elective course selections, Curricular Officers enter this information in the Curricular Officer Database. As deviations are made from the idealized course matrix, students in the same Curriculum Section may no longer take the same courses each quarter, splitting curriculum sections into Student Course Groups. [Ref.30]

c. Non-U.S. Military Officer Students

International, civilian and enlisted students may not follow the Curriculum Course Matrix completely or may take other courses that expose them to information with which U.S. military officers may already be acquainted. These students may also have restrictions from their sponsors concerning how many courses they may take or how long they may stay at NPS. Consequently, Curricular Officers may have to modify the course matrix information entered in their database for these students. During the Winter quarter of AY 1992, 11% of NPS

students were non-U.S. military officer students (see NPS Students Quarterly Enrollment by Curriculum Specialty sheet in Appendix C). [Ref.1] and [Ref.30]

2. Management Analyst

During the Forecasting phase, the Management Analyst acts as a liaison between the Curricular Officers and the academic departments, collecting data needed to make an accurate forecast. Using the Student Input Sheet and student-course information entered into the Curricular Officer Database, the Management Analyst runs the mainframe computer's Forecast Program to project ahead on-board student files and merge them with estimated new student course demands. The Management Analyst then works with the departments to produce a Tentative Course Schedule for the upcoming academic year. [Ref.2] and [Ref.31]

3. Academic Departments

Once course requests have been established, the next step to forecasting is planning for the resources necessary to meet student course demands. Academic departments, in charge of establishing, maintaining and instructing the courses students take, project ahead for a year or more the courses they need to offer and the instructors they need to teach them. Using the Management Analyst's Forecast Program outputs as a guide, the departments determine which courses they should offer during each upcoming quarter of the forecast.

Departments must also look at how many students will require which courses and forecast the number of course segments into which each course may be required to be divided. Given a course and the number of segments that may need to be taught, departments then determine who among their faculty members is both qualified and available to teach each course segment (i.e., which faculty members will not be engaged in research or other pursuits that would prevent them from teaching courses). Finally, departments must match forecast faculty demands to their budget to determine whether they can meet forecast student course demands. [Ref.31]

Once departments have forecast which courses they can support and the quarters during which they can offer them, this information is reported on a Course Projection sheet and a Tentative Course Schedule for the upcoming academic year. [Ref.31]

In 1991, the Computer Science Department Course Projection sheet indicated that department would offer all but a few of its 49 possible courses twice, every other quarter, during AY 1992, with an average of 52% of its possible courses being offered during any given quarter. Based on AY 1991-92 quarterly schedules over the course of a year, this department could also forecast that 75% of its courses would not have to be segmented and that courses that did would add an extra 40% teaching load requirement (i.e., the number of course segments was 40% over the number of courses scheduled). They could

also predict that 61% of the 33 faculty members that would teach that year (of 38 total) would be teaching courses during any given quarter, and that each faculty member would teach an average of 1.6 course segments each quarter (see Course Projection example in Appendix C). [Ref.1:p.174-181]

4. Class Schedulers

The Forecasting phase is not as relevant to the Class Schedulers as to others involved in the scheduling process. Also, almost the entire time that the Class Schedulers have to conduct scheduling activities is devoted to the other phases of the process. However, during the first four weeks of every quarter, the Class Schedulers perform some forecasting duties by constructing Regular Classroom and Laboratory Schedule Cards and Final Exam Schedule Cards anticipated for the upcoming quarter based on those needed for past quarters. Often Instructor Schedule Cards are also constructed at this time using the same instructors from the last quarter and whatever information the Class Schedulers have been able to attain about which faculty members will not teach during the quarter being scheduled. In the Computer Science Department example in the last subsection above, 60% of the faculty members who taught one quarter could be expected to teach the next quarter as well, so this practice has merit. [Ref.4]

C. PRE-SCHEDULING

The Pre-Scheduling phase of the NPS scheduling process is the activity of gathering scheduling data and turning it into information required to construct a schedule. The Pre-Scheduling phase includes most scheduling activities that take place during the first four weeks of the quarter before the quarter being scheduled. Basically, participants in this phase determine some of the preliminary pairing information described in Section A.

The primary directives for this phase are NAVPGSCOL Instruction 5010.3B, "Class Scheduling Procedures", and the Pre-Scheduling Activities Memorandum from the Office of Registration and Scheduling (or Registrar's Office) [Ref.23] and [Ref.32]. The primary outputs of this phase are the Curricular Officer Report, the Department Chairman Report, and a set of Student Course Group Schedule Cards.

1. Schedule of Events

More than any other phase, the Pre-Scheduling phase is regulated by a tight time schedule. During the four weeks that cover this phase, many transactions must occur between all parties associated with the NPS scheduling process in order to gather the requisite information needed by the Class Schedulers to construct the quarterly schedule. The schedule of events, the same for every quarter, is directed by the Pre-Scheduling Activities Memorandum, which is delivered to all

Curricular Officers, Academic Associates and Department Chairmen during the first week of the quarter before the quarter to be scheduled. The time schedule for the Pre-Scheduling phase follows:

- By COB (close of business) on Wednesday of Week 2 - Curricular Officers ensure course information is entered into the Curricular Officer Database for on-board and forecast students.

- By 0900 on Friday of Week 2 - Management Analyst delivers first iteration of Curricular Officer Report to Curricular Officers and first iteration of Department Chairman Report to departments.

- By 1200 on Wednesday of Week 3 - Department Chairmen provide Curricular Officers and the Management Analyst with Summary Listing/Course Offerings.

- By 1200 on Friday of Week 3 - Management Analyst enters Course Offerings into Curricular Officer Database and delivers Exception Listing to Curricular Officers.

- By COB on Wednesday of Week 4 - Curricular Officers update student course requests based on changes resulting from the Summary Listing/Course Offerings.

- By 1000 on Friday of Week 4 - Management Analyst delivers final iteration of Curricular Officer Reports, second iteration of Department Chairman Reports and Student Course Group Schedule Cards to the Class Scheduler.

2. Curricular Officer Report

The Curricular Officer Report consists primarily of student course request information obtained from entries made by Curricular Officers to the Curricular Officer Database. Until recently, it was the only report that associated student names with Student Course Groups, but names can now be found

on Student Schedule Cards as well. Much of the information for the report was entered during the Forecasting phase and is verified by Curricular Officers during this phase.

a. Initial Iteration

During Week 1 of the quarter preceding the quarter being scheduled, Curricular Officers review database entries to ensure they are updated based on the Tentative Course Schedule, Course Projection sheets, Option/Emphasis Area Declarations and the Student Input Sheet. By close of business on Wednesday of Week 2, they are required to have finished reviewing their entries. The Management Analyst then uses the Schedule Program to create an initial iteration of the Curricular Officer Report. The printout is separated by curricular program and delivered to its respective Curricular Officers by 0900 on Friday of Week 2. [Ref.2], [Ref.30] and [Ref.32]

b. Final Iteration

After receiving the initial iteration of the Curricular Officer Report and the Summary Listing/Course Offerings of each academic department during Week 3 of the Pre-Scheduling phase, Curricular Officers frequently display both reports so students can assist them in ensuring courses the students need have been entered for them. If courses students originally requested are not on the Summary Listing, they must select other courses to replace them that will be

offered. Students also select elective courses to replace place-holder numbers (3999 or 4999) found on the Curricular Officer Report.

After entering Course Offerings information into the Curricular Officer Database, the Management Analyst constructs an Exception List that reflects discrepancies between Curricular Officer entries, Course Offerings and the On-Line Catalog (e.g., course numbers that don't exist or courses that won't be offered). The Exception List is delivered to Curricular Officers by 1200 on Friday of Week 3. [Ref.2], [Ref.30] and [Ref.32]

Any changes made by students to course requests in the initial iteration and any corrections required as a result of the Exception List are entered into the Curricular Officer Database by Curricular Officers by close of business on Wednesday of Week 4. This is the final opportunity for students to change course requests until the Post-Scheduling phase at the beginning of the scheduled quarter. A final iteration of the Curricular Officer Report is prepared by the Management Analyst based on these information updates and delivered to the Class Scheduler by 1000 on Friday of Week 4. [Ref.30] and [Ref.32]

3. Department Chairman Report

The Department Chairman Report contains primarily scheduling information about the courses students have

requested. During the Forecasting phase, departments forecast the courses they could support during future quarters. Their Course Projections sheets and the Tentative Course Schedule incorporated this information. During the Pre-Scheduling phase, departments verify their forecasts, and finalize dividing courses into segments and assigning instructors to teach offered courses.

a. First Iteration

Between Wednesday and Friday of Week 2 of the Pre-Scheduling phase, the Management Analyst uses the Schedule Program to create a first iteration of the Department Chairman Report using information in the Curricular Officer Database. Entries for the number of course segments, the instructor(s) who will teach each segment, and the room(s) in which the course segment(s) will be taught are left blank. By 0900 on Friday of Week 2, the first iteration printout is separated by department code and distributed to applicable departments. [Ref.2] and [Ref.32]

Each department matches the first report iteration to their forecast of courses expected to be offered for that quarter. Based on the courses students actually request, the department's own criteria of the minimum number of students for whom they will offer a course (usually about four to six), on current faculty availability and on any changes that may have taken place since the forecast was made, departments

create a Summary Listing. By 1200 on Wednesday of Week 3, this list is distributed to Curricular Officers, Academic Associates and the Management Analyst. [Ref.31] and [Ref.32]

b. Second Iteration

Upon receipt of the Summary List/Course Offerings, the Management Analyst enters the course numbers into the Curricular Officer Database in order to construct an Exception List. Curricular Officers use it and the Course Offerings to update student course requests. By 1000 on Friday of Week 4 of the Pre-Scheduling phase, the Management Analyst constructs a second iteration of the Department Chairman Report and delivers it to the Class Schedulers.

c. Third Iteration

Constructing the third iteration of the Department Chairman Report belongs to the Scheduling phase of the NPS scheduling process and is treated in that discussion.

4. Student Course Group Schedule Cards

The Management Analyst uses the Schedule Card Program to extract student and course information from the Curricular Officer Database and create Student Course Group Schedule Cards. The cards are printed by index number, derived from a primary sort on the Curricular Office code (e.g., CT) and an ascending alphabetical sort of Student Course Groups' codes (e.g., PL1101). After printing the report, the sheets are

burst into single cards and the cards delivered to the Class Schedulers by 1000 on Friday of Week 4. [Ref.2] and [Ref.16]

5. Class Scheduler Preparations

By 1000 on Friday of Week 4 of the Pre-Scheduling phase, the final iteration of the Curricular Officer Report, the second iteration of the Department Chairman Report and a set of Student Course Group Schedule Cards are delivered to the Class Schedulers, who prepare them for the Scheduling phase. [Ref.4] and [Ref.32]

The final iteration of the Curricular Officer Report consists of two copies of a plain white computer paper printout. The Class Schedulers keep one of the copies, separate the other by curricular program, attach memorandums to the separated sections and deliver them to the applicable Curricular Officers via the Management Analyst. [Ref.4], [Ref.32] and [Ref.33]

The second iteration of the Department Chairman Report comes in two forms. The first is two copies of a plain white computer paper printout and the second is a three-part green-lined computer paper printout consisting of an original and two carbon copies of each page. All parts of the second iteration are given to the Class Schedulers, who separate them by department. The Class Schedulers retain one copy of the white plain paper printout and the three-part green-lined printouts and the second plain white printouts are delivered

to applicable departments, with an attached memo entitled "Submission of [Spring] Quarter AY [1992] Teaching Worksheets" that give departments guidelines on how to fill in information of the third iteration of the report. [Ref.32] and [Ref.33]

D. SCHEDULING

The Scheduling phase of the NPS scheduling process is the activity of transforming scheduling information collected during the Pre-Scheduling phase into a comprehensive course schedule and individual schedules for students, instructors and rooms. This phase begins on Week 5 and ends during Week 12 of the quarter preceding the scheduled quarter. [Ref.4]

The process of scheduling courses is divided into two parts, first scheduling courses for the regular 11 weeks of instruction and then scheduling course final examinations in the first four days of the 12th week. [Ref.4] and [Ref.30]

The responsibility for the Scheduling phase is that of the Class Schedulers. Departments provide the Class Schedulers with directions on how many segments to create for each course, instructors that will teach the course segments and requirements instructors have for the courses segment(s) assigned to them. Unless otherwise directed on the third iteration of the Department· Chairman Report, the Class Schedulers determine which students will attend each course segment and select time periods and rooms for the lecture and lab components of each course segment. The primary outputs of

this phase are a Master Instruction Schedule and the completed Student Schedule Cards, Instructor Schedule Cards, Regular Classroom and Laboratory Schedule Cards and Final Exam Schedule Cards. [Ref.4]

1. Department Chairman Report Third Iteration

The third iteration of the Department Chairman Report involves manual entries by the respective departments. Usually this responsibility is delegated by the Department Chairman to a faculty member, who often employs an assistant that maintains the department scheduling-related records [Ref.31]. For each course they have offered, departments decide if it will be divided into segments, and if so, into how many segments, which instructors will teach it and what special conditions are required (e.g., no final examination or a required room or time). All other entries are optional. [Ref.32] and [Ref.33]

The portion of the second iteration of the Department Chairman Report each department receives consists of one copy of the plain white printout and the three-part green-lined printout. Departments use the white printout as a rough draft for the third iteration and type or write their final entries on the top sheet of the three-part green-lined printout. By 0900 on Wednesday of Week 5, they return the original top sheet and the first carbon copy to the Class Schedulers and retain the second carbon copy for department records.

a. Course Segments

Based on the forecasted number of students that are expected to take a certain course, departments determine a tentative number of segments for each course. The final determination is made in the Scheduling phase. [Ref.31]

Although there is no absolute rule, classroom capacities and official guidance have limited the number of students per course segment to between 25 and 30. Since at least 1963, administrative guidance has recommended limiting the number of students in a course segment (i.e., class) to 25 [Ref.12]. Room seating capacities have physically limited most classes to no more than 30 students.

A survey of the 71 classrooms and 35 laboratories used for teaching courses at NPS shows a maximum seating capacity of 2220 students in all classrooms and about 450 in laboratories. Of the 71 classrooms, 7% seat under 20 persons, 30% seat 20-29, 34% seat 30-34, 23% seat 35-49 and 6% seat 50 or more, so nearly 70% of NPS classrooms limit the number of students per course segment to no more than about 30-35.

During the Winter quarter of AY 1992, 17% of the 327 courses offered required segmentation. Of these, 78% were divided into two course segments, 15% into three course segments and only 7% into four or more segments, with a maximum of seven. An average of 21 students were enrolled in each segment of divided courses, ranging from 8-38 students per class, with only 3% of the segments having less than 10

students. An average of 19 students enrolled in undivided courses, ranging from 1-46 students, with 35% of the courses having less than 10 students. An average of 90 students were assigned to seminar-type courses, ranging from 27-221 students per course.

In general, if a segmented course has a lab component associated with it, each segment will have its own lab period. However, there may be multiple lab segments associated with one course segment if lab space is limited or the lab requires more instructor-student interaction. In the Winter quarter of AY 1992, 39% of the 327 courses offered had both lecture and lab components. Of these, 7% had only one course lecture segment, but two or three course lab segments.

Departments are required to indicate whether a course will be segmented or not and into how many segments it is to be divided. Any course not indicated will be considered by the Class Schedulers to be taught as one class. While departments sometimes specify which students will be assigned to course segments, this complicates scheduling and student assignments are usually left to the Class Schedulers.

b. Assigning Instructors

All courses at NPS are taught by faculty members. There are no teaching assistants. During the Forecast phase, faculty instructors are tentatively assigned to teach courses a year or more in advance. Faculty are selected to teach

specific courses based on qualifications and availability to teach during the forecast quarter. [Ref.1] and [Ref.31]

Course segments may be taught by different instructors. Instructors who teach the lecture component of a course often also teach any lab components. On some occasions, more than one instructor may be assigned to a course segment, either to teach together or sequentially. Also, while one instructor may teach the course segment, there may be more than one instructor assigned to teach any lab component of the course. [Ref.4]

Departments are required to assign instructors to all course segments on the third iteration of the Department Chairman Report. For each course segment, the instructor's last name and department code (e.g., Dolk AS/Dk) are entered.

c. Assigning Classrooms or Laboratories

There are five buildings at NPS (a sixth is under construction) with classrooms and laboratories. Classrooms generally contain desks or chairs and tables, plus blackboards and viewgraph equipment. They may contain maps, projection screens or other teaching aids. Laboratories generally differ from classrooms by their specialized equipment or equipment support (e.g., power supplies). Although lab components may be taught in classrooms and sometimes lecture components taught in laboratories, if a course lab component is assigned

to a laboratory room, it is generally because the lab requires the use of special equipment. [Ref.4]

At NPS, there are 71 rooms used as classrooms in which any course may be scheduled and 35 rooms designated laboratories that generally support only certain courses. Some classrooms are placed on "loan" to groups for their sole use. In 1991, five classrooms were loaned out on a temporary basis and excluded from normal scheduling. [Ref.4]

Although departments indicate specific rooms for courses in the third iteration of the Department Chairman Report is they are required for the course, Class Schedulers usually selects the rooms. Rooms are selected for courses based on the number of students enrolled in the course, the number of segments into which the course has been divided, and other scheduling conventions (see Section D3 for details). [Ref.4], [Ref.31] and [Ref.32]

d. Instructor Requirements and Preferences

Indicating instructor requirements and preferences on the third iteration of the Department Chairman Report has been an ongoing occurrence at NPS since at least the 1950s [Ref.14]. Attempts were made in the late 1960s to reduce the number of preferences, but their impact on scheduling continues [Ref.15]. Although departments are requested to clearly indicate requirements as opposed to preferences, entries vary widely between departments and remain the largest

source of ambiguity and variability in the scheduling process [Ref.19] and [Ref.33]. When it is not clearly marked that a time or room is required, the Class Scheduler assumes an entry to be a preference. When scheduling the course, the request is granted if at all possible, but only if it there are no conflicts with courses that have required times or rooms.

In the Winter quarter of AY 1992, only one of the 39 scheduled courses offered by the Administrative Sciences Department, for example, did not have requirements or preferences for rooms or time periods on their Department Chairman Report. 44% of the courses had requirements (36% time periods and 21% rooms) and 98% had instructor preferences (98% time periods and 38% rooms).

2. Class Scheduler Preparations

Before the Class Schedulers can start to write the schedule for a course, materials from the Pre-Scheduling phase must be prepared.

a. Schedule of Events

The "Dates for Scheduling Operation for Quarter [Number/Name/Year]" sheet gives specific dates relevant to the Class Schedulers' participation in the NPS scheduling process. A generic example of the Class Schedulers' schedule of events, applicable to each quarter, follows:

- Friday, Week 4 - receive Curricular Officer and Department Chairman Reports; send reports to their respective offices.

- Wednesday, Week 5 - receive Department Chairman Reports back from departments.

- Wednesday-Friday, Week 5 - make changes to and create a full set of Instructor Schedule Cards.

- Weeks 6-8 - select time periods for each course.

- Week 9 - select rooms for each course; photocopy Student Schedule Cards; enter course schedule information into the mainframe FOCUS system.

- Week 10 - photo Instructor Schedule Cards; select times and rooms for course final exams.

- Week 11 - enter course final exam information into FOCUS system to generate the Master Instruction Schedule; distribute Student and Instructor Schedule Cards to Curricular Officers and Academic Departments; proofread rough draft of the Master Instruction Schedule and send a copy to the Registrar.

- Friday, Week 11 - send Master Instruction Schedule to the Print Shop.

- Wednesday, Week 12 - Print Shop gives the Mail Room copies of the Master Instruction Schedules to distribute to all concerned.

b. Class Scheduler Binders

To prepare for the Scheduling phase, the Class Schedulers have assembled three binders:

- BINDER #1 - "Scheduling Data and Document Reference" - a set of documents and directives that guide Class Schedulers through the scheduling process and contain data needed to perform their duties.

- BINDER #2 - NPS Telephone Book - contains names, office numbers, phone numbers and organizational codes for all parties associated with the scheduling process.

- BINDER #3 - "Instructions for Producing the Master Schedule" - step-by-step instructions on how to enter schedule information into the mainframe FOCUS system to generate and print out a Master Instruction Schedule.

c. Pre-Scheduling Reports

In addition to binders containing scheduling procedure information, the Class Schedulers obtain further data and information from the Pre-Scheduling phase reports. After their entries are made, departments return the original and first carbon copy of the three-part version of the third iteration of the Department Chairman Report to the Class Schedulers. The Class Schedulers retain the original and deliver the carbon copy of each third iteration to the NPS Bookstore so they may verify the number of books ordered for each course. [Ref.4], [Ref.23], [Ref.32] and [Ref.33]

The outside of each copy of the Curricular Officer Report is marked with the name of the curriculum office, its code and the quarter and year being scheduled (e.g., Computer Technology, Code CT, AY '92, Spring, Quarter 3). Department Chairman Reports are similarly marked with their names and codes. [Ref.4] and [Ref.33]

d. Schedule Cards

Schedule Cards are the primary tool used to construct course schedules. Each type of card can be readily identified by its color or by the color code marked on it.

(1) Student Schedule Cards. Student Schedule Cards are separated by curricular program, sorted by index number, and sent to the Print Shop to be trimmed to the same size with their edges made smooth. After they are returned, a cover

card is added to the set of cards for each curricular program, on which the Class Schedulers type the curricular program's name and code, the first letter of the curriculum sections represented by the group of cards (e.g., Computer Technology, Code 37, "C" for CS and "P" for PL and PM), and the quarter and year being scheduled (e.g., Winter AY 1992). Each set of cards is further distinguished by marking them on their edges with a color code from the Student Schedule Cards Color Chart so an individual card in a group of cards can be recognized at a glance as belonging to that group or another without having to read any information on it. See Appendix C for the Student Schedule Card Color Chart and Student Schedule Card examples.

The Class Schedulers also prepare the Student Schedule Cards for scheduling by checking for discrepancies, such as missing cards (i.e, missing index numbers), and report any discrepancies to the Management Analyst for resolution. At the same time, Class Schedulers note and mark on the E-Z Class Demand List any unusual combinations of courses assigned to the Student Course Groups that will be more difficult to schedule later, such as courses starting with EX indicating students taking an "experience tour" with all "accelerated" courses or combinations of "refresher" quarter courses with regular courses (see Appendix A for explanations).

Figure 3.1 shows the number of Student Schedule Cards required for each quarter for AY 1979-1992, which has increased from about 700 to nearly 1100 (see Section A1).

(2) Instructor Schedule Cards. A tentative set of Instructor Schedule Cards is created by the Class Schedulers during the Forecasting and Pre-Scheduling phases, based on the instructors who taught courses during the previous quarter. A final set of Instructor Schedule Cards is constructed during Week 5 from instructor assignments entered on the third iteration of the Department Chairman Report.

The number of Instructor Schedule Cards for AY 1991 averaged 270 out of about 465 possible NPS faculty members, i.e., 58% of all faculty taught during any given quarter. This closely matches the 61% of the faculty who taught in the Computer Science Department example in the description of the Forecasting phase in Section B3.

(3) Room Schedule Cards. The Regular Classroom and Laboratory Schedule Cards and the Final Exam Schedule Cards are created by the Class Schedulers during the Forecasting phase. There are rarely any changes in the rooms reserved for teaching courses, except for an occasional room that is "loaned" out. Any changes that do occur are made as the information becomes available during any phase of the scheduling process. The 71 classrooms and 35 laboratories reserved for teaching in 1992 have remained fairly constant for at least the past ten years.

e. E-Z Class Demand Listing

A report entitled "E-Z Class Demand Listing" is available to the Class Scheduler from the Registrar Database. The information it contains on the number of students expected to enroll in each course is used by Class Schedulers to get a rough idea how many courses will be segmented and which courses affect the most students. Courses with many students require a greater amount of effort writing schedules for them and may more likely conflict with other courses, so these courses are scheduled ahead of courses with less students (see Guidelines for Setting Priorities in Appendix C).

Since the E-Z Course Demand Listing contains a list of every course offered for that quarter, by department, and little else that would fill up the page, Class Schedulers find it a convenient device on which to write notes about each course from information contained in the Department Chairman Reports, such as the instructor's code, the number of course segments, any requirements, instructor preferences and the status of scheduling for each course.

Until recently, the report contained no lines to separate its fields or the lines of information printed for each course. To be able to use it effectively for note writing, the Class Schedulers prepared the report by drawing horizontal lines between each course and vertical lines between each column, including new columns so the Class Schedulers could write in other information about the course.

In the Winter quarter of AY 1992, the Senior Programming Analyst, Lloyd Nolan, modified the program that created the report to include lines. [Ref.4] and [Ref.20]

3. Completing the Schedule Cards

With all materials prepared, the Class Schedulers are now ready to complete the schedule cards and construct a Master Instruction Schedule. The usual division of labor between them has been to divide courses to be scheduled by department, with the most experienced person scheduling departments whose courses have technical lab components, since these require the most scheduling expertise, and the other person scheduling departments with less complex courses.

Completing the Schedule Cards, the heart of the NPS scheduling process, is not a matter of just following a set of simple straightforward procedures. This is particularly true under the present manual process. Our observations have been that, after a long exposure to scheduling, courses tend to take on a "personality" that the Class Schedulers can recognize. This "personality" may be a reflection of the personality of the instructor(s) who regularly teach them and their preferences for times and locations, but nevertheless, the Class Schedulers are able to use this acquired knowledge to get a "feel" for where courses can fit in the schedule. This expert knowledge enables the Class Schedulers to rapidly construct a schedule, with far fewer initial conflicts and in

far less time (by our estimation) than it would take an inexperienced individual with a complete knowledge of the scheduling process.

a. Guidelines for Setting Priorities

A rough set of guidelines for setting scheduling priorities for courses with certain characteristics has emerged from the collective experiences of Class Schedulers over the last 25+ years. Although the present "Guidelines for Setting Priorities for Scheduling" and "Guidelines for Scheduling" sheets used today are more definitive, the steps they describe are very similar to the "Steps in Scheduling" sheet created nearly 25 years ago by the first Class Scheduler (see Appendices B and C). [Ref.5]

In general, courses are scheduled first if they have required times or locations (e.g., meetings or seminars), if they are taught outside the regular instruction period (e.g., refresher courses, which are taught the last six weeks of the quarter and may conflict with final exam scheduling), if they affect a large number of students (i.e., have multiple segments) or if they have lecture or lab components that take up large blocks of time (e.g., three hour labs). Binder #1 contains supplementary information to determine which students and instructors are in this type of event or course.

In addition to the informal set of priorities written on the Guidelines for Setting Priorities sheet, there

are other "unwritten" or implicit priorities that affect the order in which courses are scheduled and establish precedences for resolving conflicts. These priorities include:

- Student course requirements come first. All students will be scheduled for all courses on their Student Schedule Cards, regardless of when or where the course has to be scheduled and whether or not requests can be met.
- Actual requirements take precedence over preferences. Some courses must be taught in specific rooms containing equipment needed to teach that course and some courses must be taught on specific days or times to take advantage of transient conditions (e.g., weather, tides).
- Instructor preferences will be honored if they do not conflict with student course requirements and hard requirements.

b. What Needs To Be Scheduled?

Not all courses taught at NPS are scheduled by the Class Schedulers. The Aviation Safety Program offers seven courses for credit that it schedules in its own classrooms. The Defense Resources Management Education Center (DRMEC) offers several programs of study ranging from 4-11 weeks in length to both U.S. and allied military and civilian defense personnel. The International Office also offers some courses. All of these are independent course programs which do not conflict with the main body of courses. However, one course offered by the International Office was added to the Master Instruction Schedule in the Winter quarter of AY 1992. Also, as a last resort, the Class Schedulers may refer a person requesting a meeting room to ask DRMEC's permission to use one of their classrooms. The Class Schedulers schedule all other

courses taught at NPS and construct schedule cards and a Master Instruction Schedule to represent this scheduling.

For each Instructor Schedule Card, the Class Schedulers identify the courses the instructor will teach from the Department Chairman Report and write these courses and their credit hours on the bottom of the card, along with number of segments the instructor will teach of the total number of segments for that course. Time periods and rooms are selected for each of these courses. The cards are then photocopied and course final exams written on the cards after photocopies are made.

Student Schedule Cards have their courses already printed on them from the Schedule Card Program. Class Schedulers write in the same time periods for each course on the card from the times selected for the course on the applicable Instructor Schedule Card(s). Time periods must be selected for all courses, and each must have its own set of time periods (because a student cannot take more than one course at a time). After they have been photocopied, course final exams are also written on these cards.

The Regular Classroom and Laboratory Schedule Card sets contain cards for all classrooms and laboratories, including those that have been loaned out, as a reminder to the Class Schedulers that these rooms can't be scheduled for regular courses. The Class Schedulers write the courses for which these rooms have been selected into the same time

periods on the room schedule cards as was selected for them on the Instructor Schedule Cards.

The Final Exam Schedule Card set contains only cards for those classrooms available to have final exams scheduled in them (no loaners). The Class Schedulers write the courses for which these rooms have been selected into the time periods selected for them during the final exam part of the Scheduling phase.

c. Scheduling Conventions

Over the years, certain conventions and "unwritten rules" have evolved which are employed by the Class Schedulers while scheduling courses:

(1) Credit Hours. The number of credit hours assigned to a course in the course catalog determines how many time periods, or hours, during the week are selected for the course, unless the Department Chairman Report indicates otherwise [Ref.1]. A course's credit hours are divided into a lecture component and a lab component. One one-hour time period is selected for the course for every credit hour of the lecture component. One additional period, or hour, is selected for every lab component credit hour.

In the Winter quarter of AY 1992, 91% of the courses offered were scheduled for the same number of hours per week as their credit hours indicated in the On-Line Course

Catalog. The other 9% were scheduled as departments directed on their Department Chairman Reports.

In the Winter quarter of AY 1992, offered courses had the following credit hours combinations:

- 41% had 4 lecture hours and no lab hours (4-0).
- 15% had (3-2) credit hours, 10% had (3-0), 7% had (4-1), 5% had (4-2), 4% had (3-1), 3% had (0-1), 3% had (0-2) and 2% had (V-0) (which means a variable number of credits determined by the instructor).
- The only other combinations of credit hours were (0-3), (1-0), (1-2), (1-3), (1-6), (2-0), (2-1), (2-2), (2-4), (3-3), (3-5), (4-4), (5-0), (5-1), (5-2) and (5-3), each representing less than 1% of the courses offered.
- The most amount of credits per course was 8, divided into 3 lecture and 5 lab credits in one case, and 5 lecture and 3 lab credits in the second case.

<u>(2) Other Time Selection Conventions.</u> Once the number of hours per week for both the lecture component and lab component (if the course has a lab) have been established, there are scheduling conventions specific to selecting time periods that are considered:

- "Once per day" convention - courses will be scheduled only once per day, e.g., a lecture hour won't be scheduled for Period 4 and another lecture for Period 7 on the same day. However, this rule does not apply to a combination of lecture and lab, e.g., a lecture hour can be scheduled for Period 4 and a lab hour for Period 7 in the same day.
- "Same time each day" convention - courses generally will be scheduled during the same time period for each day they are scheduled during the week, e.g., if the course is scheduled for Period 4 on Monday, it is scheduled for Period 4 on all other days it is scheduled.

- "Two hours maximum" convention - generally, the Class Schedulers will not schedule a course lecture component for more than two hours of consecutive instruction, unless so directed on the Department Chairman Report. Three hour labs components are frequently directed in the reports.

- "Separate classes" convention - unless requested on the Department Chairman Report, Class Schedulers attempt not to schedule course segments taught by the same instructor for consecutive time periods.

- "Lab after lecture" convention - course lab components are generally scheduled later in the week than at least the first lecture component for that course.

- "Multi-hour lab" convention - course lab components with more than one credit hour are usually scheduled as one lab of up to three hours long versus dividing the lab into separate periods.

- "Lunch period" convention - Period 5 (1200-1300) is left unscheduled, if possible, as a lunch period for students and instructors. If Period 5 has to be scheduled, an attempt is made to not schedule either Period 4 (1100-1200) or Period 6 (1300-1400) for those affected.

- "Period 8-9 and Friday labs" convention - Periods 8 and 9 (1500-1600 and 1600-1700) are frequently reserved for the lab component of courses that have both lecture and lab components, (although either lecture or lab components may be scheduled during any period). Fridays are reserved for labs when other times in the week can't be found.

In the Winter quarter of AY 1992, these conventions were observed by the departments and Class Schedulers with the following consistency:

- "Once per day" - all but one course followed this convention.

- "Same time each day" - 91% of course segments scheduled followed this convention.

- "Two hours maximum" convention - 60% of lecture segments were scheduled for more than one hour at a time; of these, only three courses were scheduled for over two consecutive hours. The longest course was four hours straight.

- "Separate classes" convention - only 34% of instructors had course segments scheduled consecutively, either because they requested this arrangement or because that was the way their courses had to be scheduled.

- "Lab after lecture" convention - 98% of course lab components were scheduled later in the week than at least the first lecture component; 70% of lab components were scheduled after all of the course's lecture segments.

- "Multi-hour lab" convention - 88% of all labs were scheduled for two or more consecutive hours.

- "Lunch period" convention - Only 11% of all courses were scheduled during Period 5; overall, Period 5 had about half the number of segments scheduled during that time as the other time periods.

- "Period 8-9 or Friday labs" convention - 79% of all course segments scheduled during Periods 8-9 were labs; 45% of all course segments scheduled on Friday were labs.

Figure 3.2 illustrates which time periods of the week course segments were scheduled during the Winter quarter of AY 1992. Note that only about half of the segments are scheduled during Period 5 (approximately 25 versus 50), that less course segments are scheduled after 1500 (Periods 8-9) than during other periods of the day, and about half as many courses are scheduled on Friday as on other days of the week.

(3) Room Selection Conventions. There are also conventions used when selecting rooms for courses:

- "Capacity" convention - select a room that has as many or more desks or tables and chairs as students in the course segment for which it is being selected.

- "Equipment" convention - select a room that has any special equipment or conditions required to support the course for which it is being selected.

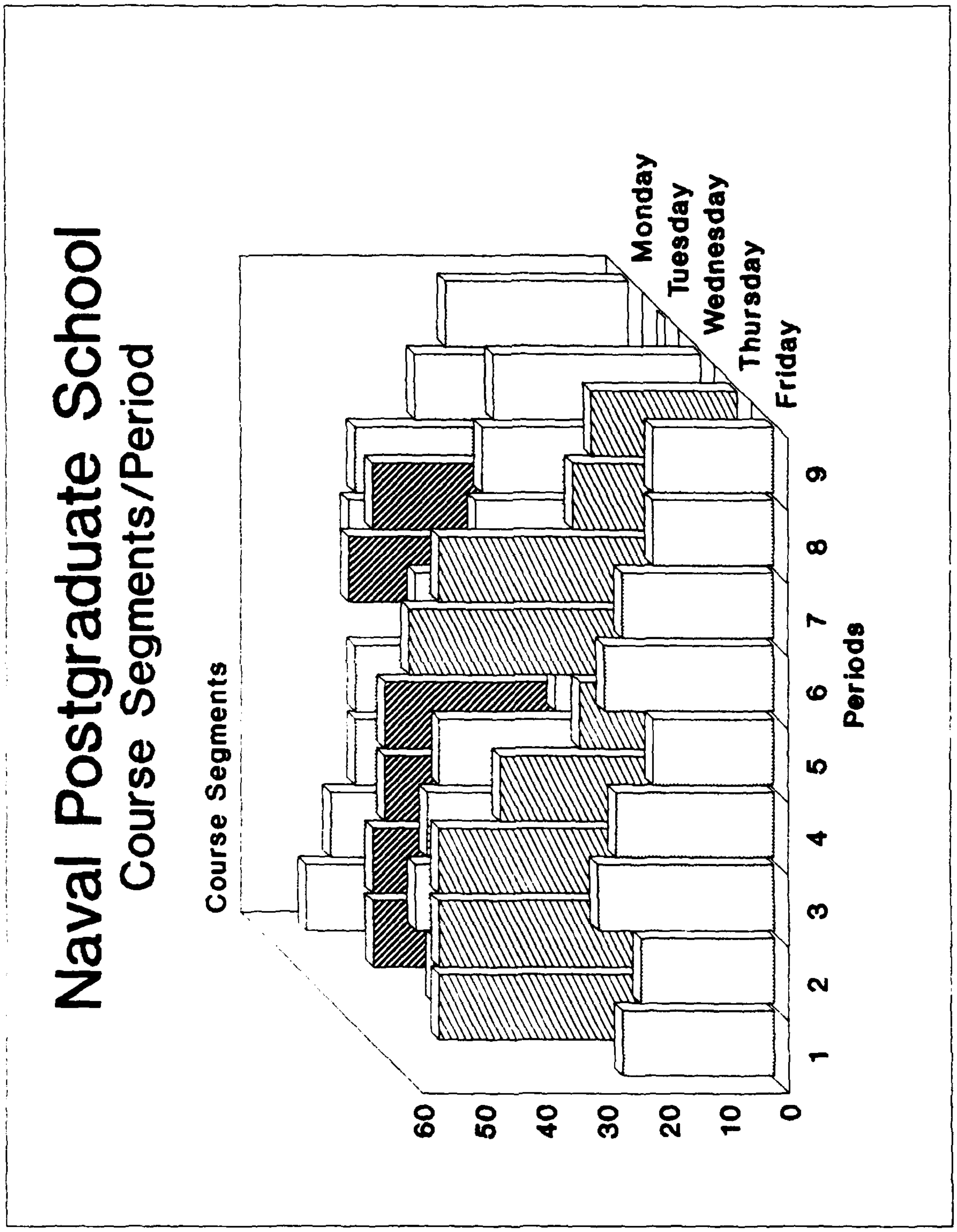

Figure 3.2 Frequency of Time Period Selection for Courses

- "Proximity" convention - schedule the course segment in the same building as the department office unless the instructor requests otherwise.

Additionally, because refresher courses are taught during Week 12, rooms selected for them are not open during the same periods for scheduling final exams. However, they are open for scheduling during the first five weeks.

d. Selecting Time Periods

The primary objective when selecting times for course instruction is to find time periods that meet event or course requirements that do not conflict with other events or courses, that is to say, no individual can be scheduled for two things at the same time.

Scheduling meetings and seminars is examined first. The ideal case of courses that don't conflict with other events or course is examined next. Finally, steps are described that can be used to resolve time period conflicts.

(1) Meetings and Seminars. Most students and instructors are members of groups whose meetings they must attend and during which time they can not be scheduled for courses. Examples of such events are department, council and committee meetings for faculty members and Superintendent Guest Lectures and Officer Student Advisory Council meetings for students. Also, some courses scheduled in the Master Instruction Schedule are actually mandatory seminar periods reserved for members of curricular programs to discuss common

formats for Curricular Officers to impart information to the members of a curricular program as a whole. Although being able to schedule students for all courses on their Student Schedule Cards takes priority over any meetings, and a course will be scheduled during a meeting time if it is the only time available, the time periods for these meetings and seminars are kept inviolable as much as possible.

The events and courses that qualify for this special consideration are listed on the "Meetings and Seminars Regularly Scheduled" sheet in the Class Scheduler's Binder #1 (see Appendix C). Membership for each meeting is on separate lists in Binder #1, which are updated by the Class Scheduler yearly or as they change.

Time periods for meetings and seminars are selected using the following steps [Ref.4]:

- Step #1 - identify the event or course to be scheduled from the Meetings and Seminars Regularly Scheduled sheet.

- Step #2 - note any required time period(s) during which this event or course must be scheduled. Only a couple of courses on the Meetings and Seminars sheet do not have required times. If there are no required times, select a time period. This is often done after all courses are scheduled, so there will be no conflict with course times.

- Step #3 - identify the individuals involved in the event or course. If it is an event, look on the applicable list in Binder #1, and if a course, on the Department Chairman Reports.

- Step #4 - retrieve the Schedule Cards for faculty members in the Instructor Schedule Cards and students in the Student Schedule Cards. If the faculty member involved in the meeting is not teaching, and therefore has no schedule card, then scheduling the person is a moot point.

- Step #5 - write the abbreviation for the event (e.g., C3 Group Mtg) or the course number (e.g., OA 0001) in the required or selected time period(s) on all applicable schedule cards for students, instructors and rooms.

- Step #6 - when writing a course onto Student Schedule Cards, locate the course number on the card and check off that the time has been scheduled. If it is an event that has been scheduled, indicate on the Meetings and Seminars Regularly Scheduled sheet that the time has been scheduled.

<u>(2) The Ideal Case.</u> The ideal case for selecting time periods would be when time periods can be selected that (1) meet course hour requirements, (2) meet scheduling conventions, and (3) do not conflict with another event or course in which anyone taking the course is involved.

The steps taken to select time periods for a course under ideal non-conflicting conditions are [Ref.4]:

- Step #1 - select a course to be scheduled from the Department Chairman Report or E-Z Class Demand Listing using the Guidelines for Setting Priorities for Scheduling for direction or any overriding criteria.

- Step #2 - locate the course on the Department Chairman Report or E-Z Class Demand Listing and note which instructor(s) have been assigned.

- Step #3 - retrieve the applicable Instructor Schedule Card(s).

- Step #4 - look on the Department Chairman Report to see which Student Course Groups have been assigned the course.

- Step #5 - retrieve each Student Schedule Card associated with the Student Course Groups from their curricular program group(s). Ensure that the course has been printed on the card. If the Student Course Group is listed on the Department Chairman Report as taking the course, but the course is not on the schedule card, this has to be resolved with Mike Troian and the Curricular Officers.

- Step #6 - determine which time periods can't be selected for this course. One method of doing this is to mark off on a piece of Schedule Worksheet all the time periods that have already been scheduled for every event or course on all applicable Instructor and Student Schedule Cards.

- Step #7 - look at the notes written on the E-Z Class Demand Listing or on the Department Chairman Report to see if there are any required or preferred time period(s) or days for this course. Also note whether the instructor has any requirements or preferences for when they don't want to be scheduled for any course. Compare these times to the times that the course that can't be selected for the course. In an ideal case, there won't be a conflict. If there is, then see steps for resolving time conflicts in the next subsection.

- Step #8 - note whether either or both of the lecture or lab components is directed to be taught consecutively on the same day; also note whether there are special instructions about the scheduling of the lab component with respect to the lecture component.

- Step #9 - the standard credit hour convention can be assumed if the instructor has not indicated otherwise. If the instructor has directed a different number of lecture/lab hours than would be selected under the credit hour convention, go to Step 10; if not, continue-> locate the course at the bottom of one of the Student Schedule Cards, on the Department Chairman Report or the E-Z Class Demand Listing. Note the number of credit hours, both lecture and lab components. One period will be selected for each lecture and lab credit hour. Go to Step 11.

- Step #10 - if the instructor has directed that a different number of lecture and/or lab hours is to be scheduled than the traditional credit hour convention, this becomes the new required number of lecture and lab time periods selected for the course (although the course retains the same number of academic credits as in the course catalog).

- Step #11 - note on the Department Chairman Report if the course has been divided into segments and how many; divide the students, i.e., Student Course Groups, between the segments so that there are approximately the same number of students in each segment. Student Course Groups are generally not divided and Curriculum Sections are placed in the same segment if possible. Mark the division and number of students in each segment on the Department Chairman Report.

- Step #12 - select a time period or periods for each required hour of the course lecture and lab components. Select a time period or periods that are still available that won't conflict with other events or course, that meets any time requirements, and that meets other scheduling conventions are much as possible. Honor instructor requests if they do not conflict with any requirements.

- Step #13 - after the time period(s) have been selected for all lecture and lab components of all course segments, write the course segments into the time periods selected for them on all applicable Instructor and Student Schedule Cards.

- Step #14 - locate the course printed on each Student Schedule Card and make a checkmark next to it to indicate that the time selection part of the scheduling process is complete for that course; repeat this step next to the course on the Department Chairman Report.

The above set of steps is not steadfast by any means. It represents one commonly observed method for selecting course time periods that the Class Scheduler use. It does present the factors that are routinely taken into consideration and the situations that may be encountered, but every quarter is different. There are always exceptions to every rule. [Ref.4]

<u>(3) Resolving Time Period Conflicts.</u> The obvious instance in the above steps during which conflicts can be discovered is in Step #6, where all time periods in the week may already be committed for other events or courses. This is the most significant type of conflict encountered, and steps must be taken to resolve it. In Step #12, one or more required time periods may conflict with one or more required time periods of another event or course, or there may not be

as many time unscheduled periods as time periods needed for the course. These situations also require that steps be taken to resolve them. The Class Schedulers may also not be able to adhere to one or more scheduling conventions. Although undesirable, inability to adhere to scheduling conventions is not a serious conflict. [Ref.4]

Some of the steps that can be taken to resolve time conflicts are [Ref.4]:

- Step #1 - identify the conflicting event(s) or course(s).

- Step #2 - note how many students are involved in the conflict. Conflicts often result when students are taking an unusual mixture of courses, some of which may be electives. If the conflict only involves one or two students, and the resolution would adversely effect the schedule of many students and/or instructors, consider trying to resolve the conflict through the Curricular Officer and the one or two students involved.

- Step #3 - determine whether Periods 5, 8, 9, and periods on Friday are unscheduled, since they are often less scheduled; they can be selected as a last resort for courses conflicting with others.

- Step #4 - prioritize the conflicting event(s) or course(s) by this convention (highest to lowest priority):
  Priority 1 - meetings or seminars with fixed times
  Priority 2 - courses with required times
  Priority 3 - courses with preferred times
  Priority 4 - all other course lecture segments
  Priority 5 - all other course lab segments
  Priority 6 - all other meetings or seminars

- Step #5 - note the number of Student and Instructor Schedule Cards, then the number of students and instructors, affected by the lowest priority course segments.

- Step #6 - decide which one of the lowest priority course segments that affects the least number of schedule cards and individuals needs to have different times selected.

- Step #7 - erase the time(s) for the chosen course from all affected schedule cards; the conflict is resolved.
- Step #8 - select the appropriate time period(s) that have become available for any remaining conflicting courses.
- Step #9 - reschedule the course for which the time periods were erased, using the steps in the ideal case.

If these steps fail to resolve the conflict, then the Class Schedulers may need to phone the instructor or department who placed the restrictions on the course, or the Curricular Officers who head the students' curricular programs to see if the situation can be resolved by changing one or more of the restrictions or course selections.

In the Winter quarter of AY 1992, Class Schedulers found 52 of 1055 Student Schedule Cards (5%) had conflicts that required employing the time resolution steps desribed above. Phone calls to instructors or departments resolved conflicts on 17 of the 52 cards. The remaining 35 cards (3%) required some form of resolution by the Curricular Officer and the students effected. [Ref.4]

e. Selecting Rooms

Rooms are generally selected after time periods, although the room may be selected first if many students are affected, thereby restricting the choice of rooms that can be selected. Unless otherwise directed, the objective is to select a room so no two events are scheduled in the same room at the same time, and to select room(s) able to accomodate the number of persons assigned to the event or course.

(1) The Usual Case. The steps that can be taken in selecting rooms are nearly the same for any event or course:

- Step #1 - identify the event or course lecture or lab segment to be scheduled.

- Step #2 - note any required or preferred room(s) for the event or course. This information may be found in notes on the E-Z Class Demand Listing, on the Department Chairman Report, or on the Meetings and Seminars Regularly Scheduled sheet for meetings and seminars. If there is no required room, go to Step #10.

- Step #3 - if there is a required room, retrieve the schedule card(s) for the required classroom(s) in the Regular Classroom Schedule Card set and for laboratories in the Regular Laboratory Schedule Card set.

- Step #4 - if there is both a required room and required time period(s), check if there is any time conflict in the required room(s); if there are time conflicts, attempt to resolve them using the steps described in the above subsection.

- Step #5 - note the total number of persons involved in the meeting or course; if it is a meeting, look on the lists in Binder #1, if a course, on the applicable Department Chairman Report.

- Step #6 - look at the seating capacity and reservation remarks on the room schedule card(s) to ensure that the number of persons involved in the meeting or course can be seated in the required room(s), unless requested otherwise, and that the room isn't being used for an incompatible use or event.

- Step #7 - note any instructor(s) involved in the event or course segment; retrieve the applicable Instructor Schedule Cards.

- Step #8 - if the capacity and reservation remarks on the room card(s) are compatible with the required room, write in the room for the event or course on all applicable schedule cards. If the room is incompatible, phone the person or organization and see if another room can be used; go back to Step #6. If there is no incompatibility, continue-> On the cards for the selected room(s), write the event abbreviation or course number, the number of persons involved in the event or course (for courses, the number of students only) and the instructor code(s). On

the Instructor Schedule Card(s), write the course number, the room number and the number of students in the course.

- Step #9 - locate the course on the Department Chairman Report and mark the course to indicate that the room part of the scheduling process is complete. If a room has been selected, this is the last step; if there is no required room, continue with Step #10.

- Step #10 - if there is no required room, determine in what building the event or course should meet, based on the group represented, i.e., attempt to schedule an event in the building that is associated with the department, academic group or curriculum office.

- Step #11 - determine if the room is a classroom or laboratory and if more than one course segment will be sharing the laboratory.

- Step #12 - note the total number of persons involved in the event or course; if it is a meeting or seminar, look on the applicable list in Binder #1, if a course, on the applicable Department Chairman Report.

- Step #13 - look through the room schedule cards at the seating capacity and reservation remarks to find one that can seat or hold the number of persons necessary and that isn't being used for an incompatible use or event.

- Step #14 - select a room for the event or course that will meet all of these criteria in this order:
  Criteria 1 - the room can accomodate all persons involved
  Criteria 2 - the room has any special equipment required
  Criteria 3 - the room is in the most appropriate building

- Step #15 - complete steps 7-9; room scheduling complete.

(2) Resolving Room Conflicts. Resolving room conflicts is a little easier than resolving time conflicts because there may be a number of rooms with the same, or more, seating capacity that may even be in the same vicinity as the room in conflict:

- Step #1 - locate the conflicting event(s) or course(s) on the E-Z Class Demand Listing or Department Chairman Report(s).

- Step #2 - prioritize the conflicting event(s) or course(s) by this convention (highest to lowest priority):
  Priority 1 - meetings and seminars with fixed rooms
  Priority 2 - courses with required rooms
  Priority 3 - courses with preferred rooms
  Priority 4 - all other courses
  Priority 5 - all other meetings and seminars

- Step #3 - note the number of Student and Instructor Schedule Cards, then the number of students and instructors, affected by the lowest priority courses.

- Step #4 - choose one of the lowest priority courses that affects the least number of schedule cards and individuals for which to select another room.

- Step #5 - erase the chosen course on the room schedule card(s); conflict is resolved.

- Step #6 - select another room using steps described in the usual case.

If these steps fail to resolve the conflict, then the Class Schedulers may need to phone the instructor or department who placed the restrictions on the course to see if the situation can be resolved by changing one or more of the room restrictions.

f. Finishing Up

After time periods and rooms have been selected for all events and courses, Student and Instructor Schedule Cards are checked to see if they have a lunch period open between 1100-1400. If they do not, their schedules are examined to see if they can be changed, using the steps used to resolve time period conflicts described above. Course lecture segments are also examined to see if their students have been as evenly distributed among them as possible. [Ref.32]

4. Scheduling Final Examinations

By about Week 10, the Class Schedulers have completed selecting time periods and rooms for all courses for the quarter's regular instruction period. Student and Instructor Schedule Cards are photocopied and ready for dissemination. The Class Schedulers then embark on a similar, but separate, undertaking of scheduling courses for final examinations. Scheduling final exams involves much the same steps as regular scheduling, but it has its own set of conventions.

All courses require a final examination or the equivalent. If an instructor prefers not to have a final exam for their course, they must so state on the Department Chairman Report and describe what is being substituted for the final exam, e.g., a term paper or project [Ref.33]. The final examination period lasts from 0800 on Monday to 1700 on Thursday during Week 12 for each quarter. NPS Instructions expressly forbid earlier final exams.

In the Winter quarter of AY 1992, 78% of all offered courses had final examinations scheduled for them. The other courses had projects or other work that took the place of the final exam.

a. What Needs To Be Scheduled?

Like scheduling courses for the regular instruction period, scheduling final exams involves selecting time periods and rooms. Unlike scheduling for the regular instruction

period, however, only one two-hour time period is required for each course, regardless of the number of segments or credit hours, and frequently more than one room is required to accommodate the students in all segments. The final exam information is written in red pencil first on the original Instructor Schedule Cards, then the Final Exam Schedule Cards and the original Student Schedule Cards.

b. Scheduling Conventions

Like the "unwritten rules" or conventions that have evolved for selecting time periods and rooms for courses during the regular instruction period, final exam scheduling has its own set of conventions:

- "All two hours" convention - schedule all course final exams for a two-hour block of time periods.
- "No more than two per student per day" convention - self-explanatory.
- "All segments take the same final" convention - all students in all course segments take the final exam for that course at the same time, even if they are taught by different instructors. This frequently requires that more than one room needs to be selected for the final exam.
- "150% capacity" convention - select rooms that will allow students to have more space than during the regular instruction period, i.e., select a room that has 150% of the capacity to seat the students needed to be seated.
- "Same rooms" convention - try to schedule final exams in the same room(s) selected for the course during the regular instruction period.
- "Adjacent rooms" convention - for final exams requiring more than one room, select rooms adjacent to each other so the instructor(s) can more easily lend any assistance to studerts and monitor the progress of the exam.

c. Scheduling Time Periods and Rooms

The steps to select time periods and rooms for final exams are similar to those used to schedule courses during the regular instruction period:

- Step #1 - identify the next final exam to be scheduled.
- Step #2 - locate the course on the Department Chairman Report or E-Z Class Demand Listing and note how many students are enrolled in the course, including faculty.
- Step #3 - locate the course on the Regular Classroom Schedule Card(s) used by the course during the regular instruction period and note the seating capacities to see if the room(s) can seat all the students in the course, using the 150% capacity convention.
- Step #4 - if the rooms do not have enough capacity to seat all the students under the 150% capacity convention, locate the Regular Classroom Schedule Cards nearest the rooms used by the course; determine if one or more of them were used for final exams, in addition to the rooms selected for the course during the regular 11 weeks, whether a combination of them would seat all students, under the 150% capacity convention.
- Step #5 - note if there is a required day for the final exam; check to see if the possible room selection(s) are open during the required day. If not, go to Step 7.
- Step #6 - if there is a required day and a two-hour time block is open in the potential classrooms, locate the Final Exam Schedule Cards representing these classrooms and write in the course, instructor code and number of students taking the final exam into this two-hour block in red pencil. Go to Step #9.
- Step #7 - if there are no required days, mark off the time periods that have already been scheduled for every final on the possible combination of rooms on a piece of Schedule Worksheet (one method).
- Step #8 - note any two-hour periods common to all potential room schedule cards; select one of the two-hour periods for the final exam.

* Step #9 - cross the checkmark next to the course on the Department Chairman Report to indicate scheduling is complete for that course.

5. Master Instruction Schedule

After time periods and rooms are selected for all courses and events, but before final exams are scheduled, the Class Scheduler enters scheduling information from the Instructor Schedule Cards into the FOCUS system, using the mainframe terminal in their office, and using instructions in Class Scheduler Binder #3. After final exams are scheduled, this information is also added to the FOCUS system from the Final Exam Schedule Cards.

After all the information is added, preliminary copies of the Master Instruction Schedule are printed. One of the copies is given to the Registrar's Office. The Class Schedulers proofread the other copies against information on the other schedule cards. If any mistakes are found, the Class Schedulers correct them on the FOCUS system. Once the Master Instruction Schedule has been verified to be error-free, the Class Schedulers send it to the NPS printshop on Friday of Week 11 to have copies made for distribution.

6. Distributing the Schedules

Three photocopies of each Student Schedule Card and two copies of each Instructor Schedule Card are made by the Registrar's Office. One set of Student Schedule Cards is retained by the Registrar to pre-register students in courses.

Two copies of the Student Schedule Cards are hand-carried to the applicable Curricular Officers. Curricular Officers use the final iteration of the Curricular Officer Report, which they retained during the Pre-Scheduling phase, to identify students associated with the Student Course Groups, each represented by a Student Schedule Card. A recent modification to the Schedule Card Program has enable the program to print up to five student names on each Student Schedule Card (Winter quarter AY 1992 was the first time this was done). If there are more than five students in a Student Course Group, the Curricular Officer must look up the other names on the Curricular Officer Report and write them on the photocopies of the Student Schedule Cards. This was the standard practice for all names on each card before the program modification.[6] The photocopy with all the names on it is photocopied again for as many students as there are names on the card so each student can have a copy of their own schedule.

Two photocopies each are made of each Instructor Schedule Card and one each of the Regular Classroom and Laboratory Schedule Cards. Sometimes more than two copies of the Instructor Schedule Cards are made if the instructor

[6] The program modification took 60 manhours to develop and implement. Considering that 96% of the Student Schedule Cards have five student names or less associated with them (1013 of 1055 cards, representing 1263 students), this modification has saved Curricular Officers a considerable amount of time spent looking up names on the Curricular Officer Report.

teaches courses belonging to more than one department. The instructor and room schedule cards are hand-delivered to the applicable departments, where a copy is frequently posted by the instructors outside their offices and outside classrooms/laboratories by the departments. The other copies are kept by the department office. If room schedules change, the Class Schedulers update the room schedule cards and send changes to the departments at the end of Week 2 of the scheduled quarter.

Copies of the Master Instruction Schedule are mailed to book publishers and others who have requested a copy and, on Wednesday of Week 12, to persons around the campus who appear on a limited distribution list, including Curricular Officers, Department Chairmen, Academic Associates and faculty members who are teaching that quarter. [Ref.4] and [Ref.33]

In the Winter quarter of AY 1992, eight of the original 1055 Student Schedule Cards were subdivided to equalize the number of students in course segments, for a total of 1063 cards. About 3200 photocopies were made of these cards and Curricular Officers made about 750 additional copies so each student could have a copy of their schedule. Two copies of the 220 Instructor Schedule Cards and one copy of the 106 room schedule cards were also made. In addition to the schedule card photocopies, 700 copies of the Master Instruction Schedule are made (38 pages each) for distribution.

All told, about 4500-5000 schedule card photocopies are made of 1450-1500 original schedule cards and 26,600 pages of Master Instruction Schedule are printed for each quarter.

E. POST-SCHEDULING

The Post-Scheduling phase of the NPS scheduling process is the activity of maintaining the schedules constructed in the Scheduling phase and deriving information from them for use in the Forecasting phase of future quarters. Post-Scheduling is any activity that takes place after the scheduled quarter has begun and is usually complete by the end of that quarter. [Ref.2], [Ref.4] and [Ref.23]

1. Changing the Final Schedule

Changes are invariably made to the final schedule, even as late as during the last half of the scheduled quarter. A copy of the Master Instruction Schedule is retained by the Class Schedulers to mark any changes made.

The Class Schedulers are the sole contact for schedule changes. The person requesting the schedule change may be an instructor who wishes to change the time period or room for a course segment or a person requesting a room in which to hold a meeting. Usually this person will phone the Class Schedulers with the proposed change, and the Class Schedulers will ascertain by looking at the original set of Regular Classroom and Laboratory Schedule Cards whether the requested room or time period is available or what rooms or time periods

are available. If an agreement is reached, the change is recorded on the room schedule card(s). After Week 2 of the scheduled quarter, any changed room Schedule Cards are photocopied, the photocopy is distributed to the applicable department and the photocopy may be posted outside room in place of the old one.

A student may change their course schedule after the quarter has begun by submitting a Change of Registration Form during the first two weeks. The form must be acknowledged and approved by the affected instructor(s) and the student's Curricular Officer and Academic Associate. The Change of Registration Form is sent to the Registrar, whose office makes the changes in the Registrar Database and retains the form. Changes to individual student schedules are not controlled or recorded by the Class Schedulers. Curricular Officers keep an accurate track of student schedules by requiring students to write their schedule on a Locator Card and maintain its accuracy, updating it as they change their schedules. Curricular Officers also update any information in their Curricular Officer Database that might affect data used in the Forecast phase as a result of student schedule changes.

In the Summer quarter of 1987, approximately 20% of the final schedule was changed by students submitting Change of Registration Forms [Ref.26:p.45]. This number has not changed substantially.

2. Schedule Analysis

After the scheduled quarter has begun, the Scheduling Data Graph is updated with information concerning the number of students enrolled in courses, the number of courses or course segments scheduled, the number of Student Schedule Cards completed and the number of classrooms available for scheduling. Copies are sent to the Registrar, the Director of Academic Planning and the Management Analyst.

The Management Analyst also extracts data from the mainframe databases and his records to construct an NPS Students Quarterly Enrollment by Curriculum Specialty sheet for persons concerned.

F. THE STATE OF THE QUARTERLY SCHEDULING PROCESS

Chapter III has detailed how the present process to construct each quarterly schedule is planned, executed and analyzed to aid future scheduling. The files and reports used by members of the scheduling team to obtain the requisite data, perform quality checks on entries and communicate between separate members of the team are elaborated upon. While strides have been made in automating sections of each phase, there are still many important areas where there is much unnecessary manual labor and paperwork generated.

Chapter IV describes an automated tool the Class Schedulers could use to aid in constructing the schedule during the Scheduling Phase and maintain the schedule during

the Post-Scheduling phae which would eliminate much of the inefficiency in the present process. It is a decision support system we have named the Naval Postgraduate School Scheduling Support System (NPS^4).

IV. QUARTERLY SCHEDULING WITH NPS[4]

A. SCHEDULING WITH A DECISION SUPPORT SYSTEM

1. Why Change the System?

The present scheduling process works. Why change it? Are there any conditions affecting the scheduling process that may change and cause the process not to work in the future? Could the process be improved to function more efficiently or economically? Could the energy and time presently devoted to certain tasks be better directed towards other tasks? These questions will be explored in the following sections.

a. Changes in the Student Population

One condition affecting scheduling is the number of students for whom courses have to be scheduled. In 1951, there were 350 students at NPS [Ref.7]. Each college constructed its own schedule. By the late 1950s, scheduling had been integrated for the whole school, but it was only a part-time job. By the late 1960s, the growing student population transformed scheduling into a full-time occupation. By the late 1980s, there were nearly 2000 students at NPS.

How big is the student population likely to become? Given the physical constraints of a limited number of academic buildings and the limited seating capacities of their classrooms, there is a maximum number of students who can

attend courses at any given time. In Chapter III, Section D, the total seating capacity for all 71 classrooms and 35 laboratories was shown to be approximately 2220 and 450 students, respectively. Not counting the new building under construction at the time of this research, this provides a ceiling of 2670 students who can be scheduled for events or courses at any given time period of the week. The average number of students attending courses during any period of the day in 1992 is approximately 750-1000.

While there appears to be room for more students, seating capacity is only one factor that determines the student population at NPS. Other factors include the NPS budget, the number of available instructors, the quotas directed by the U.S. Navy for each curriculum, and even the parking capacity of the school, all of which are limited. Although the student population has increased substantially and could hypothetically grow, the likelihood of much larger student populations at NPS is small.

b. Changes in Student Opportunities

What other scheduling conditions have changed? Are there conditions that might be compounded by an increased student population? The number of courses students take has not changed much, but the number of programs which they can select has increased. This in turn has increased the number of Curriculum Course Matrices and the number of courses that

have to be scheduled. In 1971, there were only 279 courses scheduled and 20 curricula, as opposed to 315 courses and 38 curricula in 1991. This diversification of student opportunities has not been dramatic enough to overburden the scheduling process, but allowing students increased opportunities has resulted in a dramatic increase in the number of Student Schedule Cards.

c. Changes in Student Selections

More important than the number of students scheduled is the number of Student Course Groups, the smallest unit of students scheduled and a measure of how much student schedules differ. One Student Schedule Card is printed for each Student Course Group. The number of Student Schedule Cards in turn dictates the potential complexity of the scheduling process by increasing the potential for conflicts between course time or room selections. The potential for conflicts is higher when more course schedules are inter-related. The interconnection of courses on the Student Schedule Cards, and thus the complexity of the scheduling problem, can be readily measured ([Ref.19:p.18, 29-31] and [Ref.26:p.16]). In the Spring quarter of 1985, all courses except those not actually associated with Curriculum Course Matrices, e.g., refresher courses, were found to be connected through Student Schedule Cards [Ref.19:p.31]. It was calculated that with the approximately 1000 Student Schedule

Cards and 420 course segments that quarter, there were about 40,000 "student conflict hours", i.e., time periods during the week where a possible conflict could arise between two students' course times or locations [Ref.26:p.57].

How constant have the numbers of Student Course Groups been? In the early 1970s, before there was much automation in the NPS scheduling process, there were only about 700 Student Course Groups [Ref.16]. By the early 1980s, that number had grown to 900, and by the early 1990s, to 1100 (see Scheduling Data Graph in Appendix C). Given that the Class Schedulers are working to capacity now, were this trend to continue, it would indicate that either more schedulers will be needed or students will have less freedom over the courses they can take.

The present scheduling process is at full capacity. Without partial automation by the Scheduling Program and FOCUS-based mainframe data management system, it would have reached full capacity earlier. If the parties involved in the process still had to contend with handwritten Academic Program cards and manually constructed reports, as they did before automation (see Chapter II), the Pre-Scheduling phase would be longer than it is now, perhaps by the same 60% as the number of Student Schedule Cards have increased since the inception of the automated system. A longer Pre-Scheduling phase would not allow the Class Schedulers sufficient time to construct the schedule under the present manual system.

How much bigger can the process get? The maximum limit is when each student has their own unique schedule, i.e., when the number of Student Schedule Cards equals the student population, another 60-70% increase over the present number. The complexity of the scheduling problem increases exponentially (2^N) with the addition of each new card. The Scheduling phase needs to be automated. A decision support system such as NPS[4] is the solution.

d. Changes in the Process

The scheduling process has undergone many changes:

- The Registrar Database was automated in the 1960s and later converted to the present FOCUS system.
- The Forecast and Schedule programs were established to automate the Forecasting and Pre-Scheduling phases.
- The Schedule Card Program automated the creation of Student Schedule Cards.
- The Curricular Officer Database was converted to the present FOCUS-based data management system.

Each automation effort has provided benefits to the NPS scheduling process for all parties:

- Users have more latitude to make changes and experiment with different scenarios.
- Entries and products can be made with greater accuracy, less redundancy and improved standardization.
- The time to perform scheduling duties has been reduced over the time required to perform the same duties manually.
- Reports are generated more quickly and communications between parties is made faster, with better response times and greater overall system efficiency.

- Students have a greater freedom of choice over what courses they may take due to a more efficient and flexible system allowing them to diversify their schedules.
- Class Schedulers can construct a Master Instruction Schedule from schedule card information with greater ease and accuracy.

Automating the Scheduling phase can bring additional benefits to all concerned. It is time to see if some form of automation could improve this last unautomated facet of the scheduling process - the actual scheduling process itself - the pairing of courses with time periods and rooms. NPS[4] attempts to do this in a way not tried before.

2. Why a Decision Support System?

Attempts to automate scheduling systems are not new to NPS or to other academic institutions. Since the 1950s, the problem of "timetabling" has been addressed in computer literature. Given a basic set of parameters (e.g., Curriculum Course Matrices, rooms and room capacities, an academic calendar), most systems have tried to solve the complete scheduling problem by some mathematical approach such as Integer Linear Programming (ILP). Given the number of degrees of freedom in the NPS scheduling process, an ILP approach would encounter an impractical number of variables, on the order of 10^7. Problems of this magnitude, like the NPS scheduling system, are called "N-P complete" and considered unsolvable. [Ref.19:p.15-20] and [Ref.26:p.20,71-72]

Even if an exact mathematical solution could be obtained, researchers have also discovered that, in addition to explicit constraints that can be easily defined, scheduling systems usually have a number of implicit ones. These implicit constraints are based on the knowledge the scheduler has of the internal workings of the organization, its operational philosophy and the personalities of its personnel, factors far less easily defined than schedule parameters. Consequently, other programs have tried to mathematically capture these implicit constraints by heuristic approaches, all with limited success. [Ref.19:p.15-20]

Decision Support Systems (DSS) approach this situation from a little different perspective. Instead of trying to capture all the "rules" of the process mathematically, they make a compromise. Rules that can be defined are used to create a mathematical model or models of the parts of the scheduling system to which they apply. Other rules that aren't as easily translated into mathematics, or that may only be known by the DSS user, are left to the user to employ in ways they know to make decisions. In this way, all rules necessary to the process are applied, but the human user is left "in the loop" to make the decisions required to produce a viable end-product.

3. What Is a Decision Support System?

a. Development of the DSS

A Management Information System (MIS) helps organizations process, store and retrieve large quantities of data. However, with a wealth of data at their fingertips, managers can easily become overwhelmed. Filters were developed that enabled managers to focus on selected information to help them make decisions more easily. As these systems evolved, they added analytical and mathematical tools to enable managers to make decisions concerning more complex situations. In the early 1970s, these systems became known as Decision Support Systems (DSS). [Ref.34:p.4]

Automated information processing systems can help the user in two areas [Ref.34:p.12]:

- Information Management - entering, storing, maintaining and reporting data in user-convenient or "user-friendly" forms.
- Data Quantification - turning data into information by consolidating it or manipulating it mathematically to produce meaningful products.

The difference between information processing systems and decision support systems is that DSS use information to help the user make decisions, rather than to just manage and report information. Where an MIS is good for tasks such as record management or tracking inventory, a DSS is especially applicable to problems involving resource allocation and distribution decisions, like those encountered during the NPS

scheduling process. DSS applications are particularly useful when the problem is unstructured, i.e. susceptible to change, when the problem requires interactive inputs from the user, when the user is required to evaluate alternative scenarios, i.e., "what if" questions, and when the user needs flexibility to adapt the system to preferences or changes in conditions that influence the decision. All of these are characteristics of the NPS scheduling process. [Ref.34:p.12-13]

Additionally, DSS are applied in areas where the complexity of the process makes the final decisions difficult to visualize by just looking at the data. These problems are usually characterized by three conditions, all found in the NPS scheduling process [Ref.34:p.23]:

- The process consists of many interdependent activities.
- There are a multitude of complex factors and issues that influence the system's behavior.
- The relationship between the parts of the system and factors that affect its performance are complicated and intertwined.

Finally, a decision support system is applicable to the NPS scheduling process in other ways:

> Unlike other information systems, the DSS will most likely be used by personnel with neither the time nor the inclination to become proficient in "computerese" jargon or technical procedures. The purpose of the DSS is to become a natural extension of the decision maker. [Ref.34:p.15-16]

The intended user of the Naval Postgraduate School Scheduling Support System DSS application are the Class Schedulers, who does not have a significant background in computer usage, nor

the time to learn a complicated computer system. The intent of NPS[4] is to assist the Class Schedulers in performing their duties more easily as a "natural extension" of the system currently in use.

An unstructured environment, a complex task, and users who are not computer knowledgeable are important reasons why a DSS application is an appealing form of automation to apply to the NPS scheduling process.

b. Components of a DSS

A decision support system consists of five components: the database, a database management system, a problem model, a presentation system and a user interface. Figure 4.1 shows how the components are related to each other. [Ref.34:p.75]

```
Database<----Database<----Database
Manager                   Manager
   |                         ^
   v                         |
Problem     Presentation     User
Model-------->System----->Interface
```

Figure 4.1 Components of a decision support system

The primary functions of these five components are [Ref.34:p.76-83] and [Ref.35:p.11]:

- DATABASE - a self-describing collection of records; the storage place for the data required by the process and the information describing the conditions and characteristics of the process.

- DATABASE MANAGER or DATABASE MANAGEMENT SYSTEM (DBMS) - the portion of the system responsible for getting information in and out of the database. The DBMS provides data maintenance functions, i.e., capabilities of data entry, retrieval, updating, deleting, sorting, and general administration of the database.

- PROBLEM MODEL - a mathematical representation of the structure and relationship between the various parts of the process; mathematical rules that emulate parts of the decision-making process that aid the user in making other, more complex decisions.

- PRESENTATION SYSTEM - the component that consolidates, arranges, sorts and displays information in a user-understandable format. The presentation system should enable the user to prescribe what range of information is to be examined and how it will be displayed; it should allow the user to query available information in whatever fashion is helpful to the decision-making process.

- USER INTERFACE - the entire DSS to the user - hides the internal working of the system, but allows the user to use the system in meaningful ways; the interactive component of the DSS. A good user interface will have the following characteristics:
  --- translates user inputs into computer instructions
  --- provides on-line instructions and guidance that assists both the novice and experienced users without interference (e.g., user-selected assistance levels)
  --- checks the validity and logic of user inputs
  --- generates appropriate and informative responses that explain results, recommend corrective actions or suggest new directions to be evaluated.

4. Applying a DSS to NPS Scheduling

The present scheduling process provides a solid foundation for the development of a DSS. The files and reports described in Chapter III describe an MIS. This allows application of a DSS as a shell on top of the present system.

In fact, almost none of the present system needs to be changed. This would make NPS^4 easier to implement, transition between the present system and NPS^4 less traumatic and the development process nearly independent of the present system.

a. Where the Present Process Leaves Off...

The largest part of the database component that would be used by NPS^4 is already present in the Curricular Officer Database and On-Line Course Catalog database on the mainframe. These databases hold almost all the information required by the Class Schedulers to construct a schedule.

Some database management functions required by NPS^4 are also on the mainframe. FOCUS controls data entry and manipulation in the Curricular Officer Database and On-Line Course Catalog database. FOCUS-based report generators present results of the Pre-Scheduling phase in the form of Student Schedule Cards, Curricular Officer Report and Department Chairman Report. Finally, a basic user interface is also present that accepts data entries and performs limited report generating functions.

The present scheduling system has no automated problem modelling component. The information that would normally be contained in a modelling component is in the Class Scheduler's mind. Thus, the present scheduling system is really more of an MIS than a DSS. NPS^4 will extend this system into a DSS.

b. ...And NPS^4 Begins

NPS^4 is a decision support system intended to support the Class Schedulers during the Scheduling and Post-Scheduling phases of the NPS scheduling process. While a DSS application could also benefit departments, Curricular Officers, and the Management Analyst, their roles in the scheduling process are outside the scope of this application at this time. Eventually, an integrated system could be developed for the whole school.

NPS^4 is intended to be compatible not only with existing hardware and software, but with the "look" and "feel" of the present scheduling process. Schedule Cards would look the same on a computer monitor screen as they do today, including the use of color codes for identification and status checkmarks to indicate schedule progress. Reports would look almost identical to those generated by present programs on the NPS mainframe. NPS^4 is intended to make the Class Scheduler feel "at home" immediately.

Yet NPS^4 has distinct and significant advantages over the present process. A fully functioning system would:

- eliminate the redundancy of having to enter time periods or rooms selected for course segments on each applicable Schedule Card,
- eliminate the need to manually erase trial schedules that didn't work out from each applicable Schedule Card,
- eliminate physical Schedule Cards altogether - NPS^4 would create, allow entries, update and sort all Schedule Cards completely within a personal computer in the Class Schedulers' office,

- automatically construct as much of the schedule as the Class Schedulers choose, or construct a suggested schedule, or part of a schedule, for comparison to the one constructed by the Class Schedulers,

- use search functions to locate possible choices for time periods and rooms to select for courses and alert Class Schedulers to existing or potential conflicts,

- use search and replace functions to automatically locate and retrieve Schedule Cards for a course being scheduled and enter selected time period(s) or room(s) on each card - Class Schedulers would no longer have to manually locate and retrieve cards from rubber-banded groups and replace them in proper order for EACH course scheduled, and

- eliminate the occasional human error of writing courses in the wrong time periods on the Schedule Cards.

NPS^4 employs an advanced user interface that would be installed on a personal computer in the Class Scheduler's office, a problem modelling component that has been tested and shown to work on actual NPS scheduling data, and supplemental databases to replace most of the papers kept in Class Scheduler Binder #1. NPS^4 is intended to be an independent add-on to the existing system. While it would connect with the mainframe computer, using an existing Local Area Network (LAN), to access the Curricular Officer Database and On-Line Course Catalog database, it would not interfere with the operations of the present system nor corrupt any data.

An important feature of NPS^4 is that the Class Scheduler can decide how much of the process should be automated depending on personal comfort or confidence in its reliability as it is implemented into the scheduling process. This idea is explored further in Chapter V.

B. HARDWARE COMPONENTS OF NPS[4]

1. Existing Hardware

The NPS mainframe that performs most of the automated portions of the present NPS scheduling process is an Amdahl 5990-500 Dual Processor System. The Curricular Officers, Management Analyst and Class Schedulers use IBM 3278 terminals connected by coaxial cables to patch panels, then to an IBM 3088-1 Multi-System Channel Communications Unit to access the mainframe computer. The Management Analyst uses an IBM 3268 printer and for the Department Chairman Report and Student Schedule Cards and an IBM 3800-3 laser printer for the Curricular Officer Report, both located in the NPS computer center. [Ref.35] and [Ref.36]

Nearly all persons involved in the scheduling process have personal computers in their offices, predominantly Zenith 248 IBM-compatibles with Intel 80286 processors, though they may also have Apple Macintoshes, Sun Sparc Stations or other makes. The Zenith 248 in the Class Schedulers' office has a 30MB hard drive with one 5 1/4" floppy disk drive. It is connected to computers in Hermann Hall (the NPS administration building) via a Local Area Network (LAN) referred to as the MIS Network [Ref.37]. Through this network, the Class Schedulers can access the same mainframe information as the hard-wired terminals via the MIS Network using TELNET and TCP/IP protocol. The Class Schedulers can also use an HP

laser printer and IBM 3268 printer, both common to the MIS Network, to print documents and reports.

2. Proposed Hardware

NPS[4] is intended to interface with existing hardware systems. The program would reside on one or two personal computers in the Class Schedulers' office and would retrieve information from and enter information into the mainframe via the MIS LAN. The primary required hardware change is replacing the personal computer in the Class Schedulers' office with faster ones with more memory. This upgrade is currently in the planning stage [Ref.4]. The make of computer required depends on software selected to support NPS[4].

Two systems considered in this research that could support NPS[4] are an Apple Macintosh IIci and an IBM-compatible with an Intel 80386 processor or better. The program chosen for the prototype presented in this thesis, HyperCard[6], runs on the Apple Macintosh IIfx computer (or more capable version) and requires version 6.0.5 of System and Finder files and a 68020 or 69030 microprocessor [Ref.37:p.17-18]. HyperCard requires a minimum of 2MB of RAM, but more when used in tandem with a requisite database manager program (at least 4MB is recommended) [Ref.37:p.22]. IBM-compatible programs with

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[6] HyperCard is a multi-functional program first commercially available from Apple Computer in 1987. It comes installed on every model of Apple Macintosh computer on which it is capable of running. [Ref.37:p.xix]

graphical user interface capabilities, such as Toolbook[7] would have similar requirements.

The selected computer(s) should also have at least a 60MB[8] hard drive to store all the information required to run NPS[4], particularly to hold the Student Schedule Cards and the database component. The program chosen to support the user interface component of NPS[4] also needs to be installed on a hard drive with an access speed of 28msec or better to run at a satisfactory speed [Ref.37:p.18]. A mouse is not absolutely essential, but is highly recommended to quickly access the graphical user interface components of NPS[4]. Both 3 1/2" and 5 1/4" disk drives would also be helpful to give the Class Schedulers the option to store scheduling information on media compatible to nearly all machines used by persons involved in the scheduling process. The laser printer currently in use by the Class Schedulers on the MIS Network is sufficient to print any reports NPS[4] would generate.

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[7] Toolbook is a graphical user interface program available through Assymetrix, Inc. It operates in the Windows environment and is designed to construct tutorials and training aids. It enables developers to construct screens similar to HyperCard.

[8] This estimate is based on the prototype, which uses about 10K per screen. 15Mb would be required to store 1500 schedule card screens. Another 15Mb would be needed to store an additional copy of the schedule cards for backup purposes. The application program, e.g., HyperCard, requires an additional 4-5Mb. More memory would be needed for databases and the NPS[4] shell itself as well as stored schedules.

A computer monitor is required to display for the NPS^4 user interface. A large monitor screen is desirable since more information can be overlaid on it and the information that appears is easier to read. The monitor ideally should be able to display several overlapping 5" x 8" (life-size) schedule cards, a menu bar, and a data entry or comment area. Color is a distinguishing tool used in the present scheduling system (e.g., color codes used for Student Schedule Cards and final exams coded in red) that could be carried over into NPS^4. A color monitor with a 12" diagonal screen would be the minimum recommended size.

If an IBM is selected, the MIS LAN already exists that is presently connected to the Class Schedulers' computer. If an Apple Macintosh computer is selected, Chapter 49 of Reference 37 gives details of how to connect an Apple Macintosh to an IBM mainframe and how to import database information, though this would have to investigated further.

C. SOFTWARE COMPONENTS OF NPS^4

This section gives an overview of existing and proposed scheduling software at NPS. Sections D-G examine each NPS^4 software component in detail.

1. NPS^4 Versions

NPS^4 will not interfere with the operation of existing software or corrupt any information in existing files. A fully functional NPS^4 could create the Master Instruction

Schedule and write this information to the mainframe in the same format used by Class Schedulers in the present process. Although a "safer" option with regard to mainframe security would be for NPS^4 to have read-only access to mainframe information, this would not use the full potential of the system and require unnecessary work for the Class Schedulers.

Different versions of NPS^4 are envisioned as it is implemented into the scheduling process. Two preliminary versions are described in this chapter:

- PROTOTYPE VERSION - retains all existing reports and documents, including physical schedule cards and papers in Binder #1. This version consists of a user interface on the Class Schedulers' personal computer(s) and contains a duplicate electronic set of schedule cards, created from accessing mainframe information, to aid Class Schedulers in their duties. The automated problem modelling component is not yet incorporated in this version.

- INITIAL VERSION - eliminates the need for physical schedule cards and most papers in Binder #1, incorporates optional use of the problem modelling component, and automatically enters Master Instruction Schedule information into the mainframe. This version consists of an expanded user interface found in the Prototype Version and makes use of supplemental databases to increase the ability of NPS^4 to aid Class Schedulers in the decision-making process. Selected schedule cards and the Master Instruction Schedule can be printed on request.

2. Databases

a. Present System

Information required by NPS^4 currently exists in automated and unautomated formats. In automated forms, it exists in the SECT file of the Curricular Officer Database and the On-Line Course Catalog database. In unautomated forms, it

exists in manual entries made during the final iteration to the Department Chairman Report and in papers contained in Class Scheduler Binder #1. This is all the information required by the Class Schedulers to construct schedules.

b. NPS^4

Preliminary versions of NPS^4 would still use both automated and unautomated forms of information. Except for information obtained by phone calls, later versions of NPS^4 could be fully automated.

The Registrar Database does not contain any information required by the Class Schedulers to produce schedules that is not also in the Curricular Officer Database. The only reason the Registrar Database is accessed by the Class Schedulers during the scheduling process is to generate an E-Z Class Demand Listing and a Professor Listing. Although both are retained in the Prototype Version, the E-Z Class Demand Listing is generated from information extracted from the SECT file and the Professor Listing is contained in a supplemental database on the Class Schedulers' office personal computer in the Initial Version of NPS^4.

The Prototype Version of NPS^4 would retain all present unautomated information. The Initial Version would convert information in Binder #1 to databases. Manual department entries on the third iteration of the Department Chairman Report would remain unautomated in both versions.

3. Database Management System

a. Present System

The mainframe's FOCUS language system performs database management functions for all scheduling information on the NPS mainframe, including entry and retrieval handling required by NPS[4].

b. NPS[4]

Supplemental databases required by NPS[4] would be managed by a commercially available personal computer program. The choice of program depends on the type of computer and the software chosen to support NPS[4]. If an Apple Macintosh IIci system is selected, a HyperCard-compatible database manager such as HyperHit[9] could be selected, although HyperCard itself may be able to handle database requirements (see Section D) [Ref.37:p.774]. If an IBM-compatible computer system is selected, a database manager such as dBASE IV[10] could be chosen, although Toolbook could handle database requirements in the same manner as HyperCard.

4. Scheduling Model

Professor David Erickson, a faculty member of the Computer Science Department at NPS, has developed a

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[9] HyperHIT is a database engine available from Softstream, Inc. that could be hooked to a HyperCard front end. It consists of a series of XCMD resources and can store both text and graphics.

[10] dBASE IV is a computer application and database management program available through Borland Corporation.

mathematical model of the NPS scheduling process called the Naval Postgraduate School Scheduler (NPSS) [Ref.26]. The program has been tested successfully on the NPS mainframe with actual NPS scheduling data. NPSS would be the primary problem model used in NPS^4. The program, currently resident on the NPS mainframe, would be accessed through the MIS LAN.

5. Presentation System

a. Present System

In the Prototype Version of NPS^4, the present programs on the NPS mainframe system (e.g., Schedule Card Program) would generate the reports used by the Class Schedulers. In the Initial Version, mainframe programs would only be needed to generate the Department Chairman Report so entries could be manually entered to its third iteration. Since preliminary versions of NPS^4 are transparent to all but the Class Schedulers, other reports involved in the Forecasting and Pre-Scheduling phase would still have to be generated to enable Curricular Officers, departments and the Management Analyst to perform their scheduling duties.

b. NPS^4

HyperCard and Toolbook, mentioned as candidates for supporting NPS^4, are both capable of generating any required reports. If more robust reports are required, such as printing the Master Instruction Schedule, a program such as

Reports[11] could do this for HyperCard-based user interfaces and IBM has similar programs. [Ref.37:p.71-85,776-777]

6. User Interface

a. Present System

A rudimentary user interface has been developed in FOCUS that is used for all automated data entry and extraction functions in the present scheduling process. It is text only, limited in options and accessed by a keyboard. Changes to the user interface require changes to the computer program.

b. NPS[4]

NPS[4] would have a sophisticated user interface accessible by either keyboard or mouse. It would have graphical components, a contextual help feature and be rich in options. Changes to the user interface could be easily accomplished at the personal computer, even by the user.

D. DATABASES AND DATABASE MANAGEMENT

To aid the Class Schedulers in scheduling meetings and seminars, the Initial Version of NPS[4] contains supplemental databases from Binder #1. This section examines how the supplemental databases could be constructed, how existing databases such as the SECT file are structured, and how mainframe information can be accessed for use by NPS[4].

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[11] Reports is a report generating program available through 9-to-5 Software that uses HyperCard XCMDs to extract data for assembling and generating sophisticated database-driven reports.

1. NPS[4] Database Construction

a. Database Theory

Databases are self-describing, automated collections of integrated records. An automated record is similar to a record in an unautomated filing system. Each subject for which a record is kept has characteristics about it kept in their record, e.g., an invoice's record has an amount and date, a person's record has a name and address. Databases store records so their relationships with other records are easily discerned, e.g., all invoices dealing with a particular company, or all persons belonging to a certain group, can be easily located. The records are not just randomly organized, but stored in an integrated structure. These relationships between records are stored in a "data dictionary", which acts as a guide to the database structure and allow other programs to access data in the database without having to know how it is stored. [Ref.24:p.11-13]

(1) Objects. Subjects about which database records are kept are called "objects" and their characteristics are called "properties". The scheduling elements described at the beginning of Chapter III, that is, students, courses, instructors, classrooms and time periods of instruction, can all be translated into objects when expressed in terms of databases. [Ref.24:p.90-91]

An object called STUDENT may represent a common group of real-life "entities", i.e., all NPS students. An actual "instance" of this object would be "Youngblood" or "Nolan", two students attending the school. These students are different people with unique characteristics, but these characteristics can be described in terms common to all students, e.g., a name and an address. The object called STUDENT likewise has properties such as Name and Address, and many others. However, only some properties are relevant to scheduling, i.e., Name identifies which STUDENT is enrolled in a course, but Address may be more important to the Curricular Officer or Registrar than to the Class Schedulers. Therefore, only object properties relevant to scheduling are considered in constructing scheduling databases.

Database objects and their properties can be described formally. Each object property has a set of possible values called its "domain", i.e., the domain of the STUDENT property Name would be a list of names of all NPS students. An object can be described in detail by an "object specification" composed of an "object definition" and a "domain definition". An object definition contains an object's properties and the property's domain. A domain definition specifies the format, length and any restrictions on the values a property can have. Like the records described above, objects can be related to other objects, i.e., students take courses. A specific object, its properties and the

relationships between it and other objects can be represented graphically by an "object diagram". [Ref.39:p.92-110]

(2) Object Relationships. The value of a database over other automated information processing methods is that the user can readily find all objects associated with a particular type of relationship, e.g., all students taking a specific course or all students in a specific curriculum. While an object diagram shows the properties of a particular object and other objects to which it is related, the relationships among all the objects in a database can also be portrayed graphically by a "relation diagram", which shows the interconnectivity of all the objects, indicating the "key" property which is unique to that object. [Ref.24:p.180-211]

b. Scheduling Objects

Besides students, instructors, classrooms and time periods of instruction, what other objects exist in the NPS scheduling process? The standard approach to this question would be to analyze the process, much as was done in the latter part of Chapter III, only with more formal methods used in software development theory (see Section G). However, the intent of NPS[4] is not to create an automated process, but to automate the existing process, to maintain existing reports so Class Schedulers can transition from an unautomated to an automated process with the least discomfort (see Chapter V for

alternative approaches). With this goal in mind, the approach will be to "reengineer" the databases, i.e., determine which objects databases must contain to construct the present end-products rather than determine which end-products could be produced from an optimally designed database.

Therefore, the objective is to specify which objects are required by the Class Schedulers to create the Master Instruction Schedule and schedule cards. This is done by a careful examination of the information that each of these reports contains.

(1) Master Instruction Schedule. Figure 4.2 shows a representation of the Master Instruction Schedule (see Appendix C for more detail).

WINTER QUARTER AY 1992

COURSE	CR HOURS	NO. STU	PROF	MONDAY PERIOD	MONDAY ROOM	FRIDAY PERIOD	FRIDAY ROOM
ADMINISTRATIVE SCIENCES (AS)							
IS4185-1	4-0	18	AS/SE	3-4	I-267		
IS4185-1	0-1	18	AS/SE			1	I-267
IS4185-2	4-0	18	AS/SS	8-9	I-267		
IS4185-2	0-1	18	AS/SE			3	I-267
			EXAM	6-7	I-323,325		

Figure 4.2 Master Instruction Schedule

The most obvious object is COURSE. Other objects are INSTRUCTOR (a more accurate name for scheduling than PROFESSOR) and DEPARTMENT (of which Administrative Sciences is actually an instance) and ROOM (e.g., I-267). Other less obvious objects are SEGMENT, divisions of each COURSE and FINAL_EXAM, both needed to describe all the objects in the report. The report itself could be represented by an object called MASTER_SCHEDULE.Table 4.1 shows the objects used in producing the Master Instruction Schedule, their properties and an example instance of the object's property for clarity. It also shows whether there is one or many possible values for each object in an instance of the report and one or many possible values for each property of an object instance. For example, there may be many FINAL_EXAMs scheduled on the report, but each FINAL_EXAM is scheduled on only one DAY, during many (more than one) PERIODs.

So far objects have been examined as separate items, but many objects in this report are related to each other. As the report itself has been represented by an object MASTER_SCHEDULE, Table 4.1 shows that a MASTER_SCHEDULE contains many DEPARTMENTs, DEPARTMENTS offer many COURSEs, COURSEs may have many INSTRUCTORs, etc.

TABLE 4.1 MASTER INSTRUCTION SCHEDULE OBJECTS

Name of Object	No. of Values	Object Properties	Example Instance	No. of Values
MASTER_SCHEDULE	one	Year	1992	one
		Quarter_Name	Winter	one
DEPARTMENT	many	Dept_Ltr_Code	AS	one
COURSE	many	Course_Type	IS	one
		Course_Number	4185	one
SEGMENT	many	Segment_Number	2	one
		Lect_Hrs	4	one
		Lab_Hrs	0	one
		Segment_Students	18	one
		Day	Monday	many
		Period	8	many
INSTRUCTOR	many	Dept_Ltr_Code	AS	one
		Faculty_Code	SE	one
ROOM	many	Building	I	one
		Room_Number	267	one
FINAL_EXAM	many	Day	Monday	one
		Period	6	many

Figure 4.3 shows how the information in Table 4.1 and relationships among the objects is translated into object diagrams. Each item in capital letters is an object. Objects below underlined objects are related to them. Other items below underlined objects are their properties. MV stands for Multiple Values, e.g., a FINAL_EXAM is scheduled on one Day, but during many (MV) Periods.

<u>MASTER_SCHEDULE</u>

Year
Quarter_Name

DEPARTMENT$_{MV}$

<u>DEPARTMENT</u>

Dept_Ltr_Code

COURSE$_{MV}$

<u>INSTRUCTOR</u>

Dept_Ltr_Code
Faculty_Code

<u>COURSE</u>

Course_Type
Course_Number

SEGMENT$_{MV}$

FINAL_EXAM

<u>FINAL_EXAM</u>

Day
Period$_{MV}$

ROOM$_{MV}$

<u>SEGMENT</u>

Segment_Number
Lect_Hrs
Lab_Hrs
Segment_Students
Day$_{MV}$
Period$_{MV}$

INSTRUCTOR$_{MV}$

ROOM$_{MV}$

<u>ROOM</u>

Building
Room_Number

Figure 4.3 Master Instruction Schedule Object Diagrams

Examining the possible values for the objects and their properties on several Master Instruction Schedules leads to object specifications. Table 4.2 shows the object definitions for a Master Instruction Schedule.

TABLE 4.2 MASTER INSTRUCTION SCHEDULE OBJECT DEFINITIONS

<u>MASTER_SCHEDULE OBJECT</u>

Year; Schedule_year
Quarter_Name; Schedule_quarter_name
DEPARTMENT; DEPARTMENT object; MV; SUBSET
[Dept_Ltr_Code]

(continued on next page)

TABLE 4.2 MASTER INSTRUCTION SCHEDULE
OBJECT DEFINITIONS (continued)

DEPARTMENT OBJECT

Dept_Ltr_Code; Department_letter_code
COURSE; COURSE object; MV; SUBSET [Course_Type,
Course_Number]

COURSE OBJECT

Course_Type; Course_type
Course_Number; Course_number_code
SEGMENT; SEGMENT object; MV; SUBSET [Segment_Number,
Lect_Hrs, Lab_Hrs, Segment_Students, Day,
Period]
FINAL_EXAM; FINAL_EXAM object; SUBSET [Day, Period]

SEGMENT OBJECT

Segment_Number; Course_segment_number
Lect_Hrs; Course_lecture_credit_hours
Lab_Hrs; Course_lab_credit_hours
Segment_Students; Course_segment_number_of_students
Day; Academic_day; MV
Period; Academic_hour; MV
INSTRUCTOR; INSTRUCTOR object; MV; SUBSET
[Dept_Ltr_Code, Faculty_Code]
ROOM; ROOM object; MV; SUBSET [Building, Room_Number]

INSTRUCTOR OBJECT

Dept_Ltr_Code; Department_letter_code
Faculty_Code; Department_faculty_code

ROOM OBJECT

Building; Room_building_location
Room_Number; Room_number_in_building

FINAL_EXAM OBJECT

Day; Academic_day
Period; Academic_hour; MV
ROOM; ROOM object; MV; SUBSET [Building, Room_Number]

Table 4.3 shows the domain definitions for the objects of the Master Instruction Schedule report.

TABLE 4.3 MASTER INSTRUCTION SCHEDULE DOMAIN DEFINITIONS

Academic_day:
    Text 9
    Name of the day of the academic week

Academic_hour:
    Numeric 1
    Hour-long period during the academic day

Course_lab_credit_hours:
    Numeric 1
    Number of credit hours assigned to lab component of a course or its course segment

Course_lecture_credit_hours:
    Numeric 1
    Number of credit hours assigned to the lecture component of a course or its course segment

Course_number_code
    Numeric 4, mask NXXX,
        where N is 0-4, XXX is course code
    Number code assigned to a course

Course_segment_number:
    Numeric 2
    Number of the segment into which a course has been divided

Course_segment_number_of_students:
    Numeric 3
    Number of students assigned to a course segment

Course_type
    Text 2
    Code for the type subject a course teaches

(continued on next page)

TABLE 4.3 MASTER INSTRUCTION SCHEDULE
DOMAIN DEFINITIONS (continued)

Department_faculty_code
    Text 2
    Code used to identify each faculty member

Department_letter_code
    Text 2
    Alpha code used to identify each department

Room_building_location
    Text 1
    First letter of the name of the building in which a room is located

Room_number_in_building
    Text 4, mask NNNA,
        where NNN is sequential number of room,
        A is letter designator for a room subdivision, e.g., A,B,C,D
    Number assigned to a room in a building

Schedule_quarter_name
    Text 6
    Name of the season at the beginning of the quarter of the academic year

Schedule_year
    Numeric 4
    Year for which the schedule is written

<u>(2) Student Schedule Cards.</u> Figure 4.4 shows a representation of a Student Schedule Card (see Appendix C for more detail - note that one useful modification has been applied to the card by adding rooms and instructors for each course segment, instead of just the course identification as on existing cards).

```
218.   PL11 2      2 STUDENTS    CT   ||     QTR 2 91-92
--------------------------------------||--------------------
 |  1  |  2  |  3  |  4  |  5         ||   8   |   9   |
--------------------------------------||--------------------
M|                IS4185-1                               |M
O|                I-267                                  |O
N|                HOBBES                                 |N
------------------------------------------------------------
T|                                           IS 4185     |T
U|                                   LECTURE IS 4200     |U
E|                                   PROGRAM CS 4203     |E
 |                                           IS 0810     |
------------------------------------------------------------
  PL11 2    IS418541---IS420040---CS420332---IS081000

  NOLAN          JS        YOUNGBLOOD      PD
```

Figure 4.4 Student Schedule Card

Student Schedule Cards have many of the same objects as the Master Instruction Schedule. However, in this case, individual students are recognized, so another object, STUDENT, is represented.

Figures 4.5 shows Student Schedule Card Object Diagrams. Tables 4.4 and 4.5 show its Object Specifications (Object Definitions and Domain Definitions), applying the same logic as that applied to the Master Instruction Schedule. In Table 4.5, all domain definitions are the same as for the Master Instruction Schedule except for those indicated.

STUDENT_CARD

Card_Number
Year
Quarter_Number

STUDENT$_{MV}$

COURSE$_{MV}$

CURRIC_PROGRAM

Program_Ltr_Code

CURRICULUM$_{MV}$

STUD_CUS_GROUP

Group_Number
Group_Students

STUDENT$_{MV}$

COURSE

Course_Type
Course_Number

SEGMENT$_{MV}$

STUDENT

Last_Name
First_Initial
Middle_Initial

STUD_CUS_GROUP

CURRICULUM

Curric_Ltr_Code

SECTION$_{MV}$

INSTRUCTOR

Last_Name

SEGMENT

Segment_Number
Lect_Hrs
Lab_Hrs
Day$_{MV}$
Period$_{MV}$

INSTRUCTOR$_{MV}$

ROOM$_{MV}$

ROOM

Building
Room_Number

SECTION

Section_Number

STUD_CUS_GROUP$_{MV}$

Figure 4.5 Student Schedule Card Object Diagrams

TABLE 4.4 STUDENT SCHEDULE CARD OBJECT DEFINITIONS

COURSE OBJECT

Course_Type; Course_type
Course_Number; Course_number_code
SEGMENT; SEGMENT object; MV; SUBSET [Segment_Number,
Lect_Hrs, Lab_Hrs, Day, Period]

(continued on next page)

TABLE 4.4 STUDENT SCHEDULE CARD OBJECT DEFINITIONS (continued)

STUDENT_CARD OBJECT

Card_Number; Schedule_card_number
Year; Schedule_year
Quarter_Number; Schedule_quarter_number
STUDENT; STUDENT object; MV; SUBSET [Last_Name, First_Initial, Middle_Initial]
COURSE; COURSE object; MV; SUBSET [Course_Type, Course_Number]

SEGMENT OBJECT

Segment_Number; Course_segment_number
Lect_Hrs; Course_lecture_credit_hours
Lab_Hrs; Course_lab_credit_hours
Day; Academic_day; MV
Period; Academic_hour; MV
ROOM; ROOM object; MV; SUBSET [Building, Room_Number]
INSTRUCTOR; INSTRUCTOR object; MV; SUBSET [Last_Name]

INSTRUCTOR OBJECT

Last_Name; Person's_last_name

ROOM OBJECT

Building; Room_building_location
Room_Number; Room_number_in_building

STUDENT OBJECT

Last_Name; Person_last_name
First_Initial; Person_first_name_initial
Middle_Initial; Person_middle_name_initial
STUD_CUS_GROUP; STUD_CUS_GROUP object; SUBSET [Group_Number]

CURRIC_PROGRAM OBJECT

Program_Ltr_Code; Curriculum_program_letter_code
CURRICULUM; CURRICULUM object; MV; SUBSET [Curric_Ltr_Code]

(continued on next page)

TABLE 4.4 STUDENT SCHEDULE CARD OBJECT DEFINITIONS (continued)

CURRICULUM OBJECT

Curric_Ltr_Code; Curriculum_letter_code
SECTION; SECTION object; MV; SUBSET [Section_Number]

SECTION OBJECT

Section_Number; Curriculum_section_number
STUD_CUS_GROUP; STUD_CUS_GROUP object; MV; SUBSET [Group_Number]

STUD CUS GROUP

Group_Number; Curriculum_student_course_group_number
Group_Students; Curriculum_student_course_group_no_of_students
STUDENT; STUDENT object; MV; SUBSET [Last_Name, First_Initial, Middle_Initial]

TABLE 4.5 STUDENT SCHEDULE CARD DOMAIN DEFINITIONS

Curriculum_letter_code
Text 2
Letter code for a curriculum within a curriculum program

Curriculum_program_letter_code
Text 2
Letter code for a curriculum program

Curriculum_section_number
Numeric 2
Number code for the section within a curriculum

Curriculum_student_course_group_number
Numeric 2
Number of a student course group within a curriculum section

(continued on next page)

TABLE 4.5 STUDENT SCHEDULE CARD DOMAIN DEFINITIONS
(continued)

Curriculum_student_course_group_no_of_students
Numeric 2
Number of students in a student course group

Person_first_name_initial
Text 1
First letter of a person's first name

Person_last_name
Text 13
First thirteen letters of a person's last name

Person_middle_name_initial
Text 1
First letter of a person's middle name

Schedule_card_number
Numeric 4
Sequential number of a schedule card in set of schedule cards

Schedule_quarter_number
Numeric 1
Sequential number of a quarter in an academic year

(3) Instructor Schedule Cards. Figure 4.6 shows a representation of an Instructor Schedule Card (see example in Appendix C). Except for an object representing this type of card, Instructor Schedule Cards have no objects not found in the Master Instruction Schedule and Student Schedule Cards.

Figure 4.7 shows the Object Diagrams for Instructor Schedule Cards. Table 4.6 and 4.7 show the Object and Domain Definitions for Instructor Schedule Cards.

```
13  AS/Hb  HOBBES, CALVIN N.    AS          QTR 2 91-92
 ______________________________________  ____________
 |  1  |  2  |  3  |  4  |  5  ||  8  |  9  |
-------------------------------------  -------------
M|                IS4185-1            IS4185-2  |M
O|                I-267               I-267     |O
N|                18                  20        |N
------------------------------------------------------
T|                                     IS 4185|T
______________________________________________________
  IS4185(4-1) 2 segments of 2
```

Figure 4.6 Instructor Schedule Card

INSTRUCTOR_CARD	COURSE	SEGMENT
Card_Number Year Quarter_Number Quarter_Name $COURSE_{MV}$	Course_Type Course_Number $SEGMENT_{MV}$	Segment_Number Lect_Hrs Lab_Hrs Segment_Students Day_{MV} $Period_{MV}$ INSTRUCTOR $ROOM_{MV}$
ROOM	**INSTRUCTOR**	**DEPARTMENT**
Building Room_Number	Last_Name First_Name Middle_Initial Faculty_Code DEPARTMENT $SEGMENT_{MV}$	Dept_Ltr_Code

Figure 4.7 Instructor Schedule Card Object Diagrams

TABLE 4.6 INSTRUCTOR SCHEDULE CARD OBJECT DEFINITIONS

INSTRUCTOR_CARD OBJECT

Card_Number; Schedule_card_number
Year; Schedule_year
Quarter_Number; Schedule_quarter_number
Quarter_Name; Schedule_quarter_name
COURSE; COURSE object; MV; SUBSET [Course_Type, Course_Number]

COURSE OBJECT

Course_Type; Course_type
Course_Number; Course_number_code
SEGMENT; SEGMENT object; MV; SUBSET [Segment_Number, Lect_Hrs, Lab_Hrs, Segment_Students, Day, Period]

SEGMENT OBJECT

Segment_Number; Course_segment_number
Lect_Hrs; Course_lecture_credit_hours
Lab_Hrs; Course_lab_credit_hours
Segment_Students; Course_segment_number_of_students
Day; Academic_day; MV
Period; Academic_hour; MV
INSTRUCTOR; INSTRUCTOR object; SUBSET [Last_Name, First_Name, Middle_Initial, Faculty_Code]
ROOM; ROOM object; MV; SUBSET [Building, Room_Number]

INSTRUCTOR OBJECT

Last_Name; Person_last_name
First_Name; Person_first_name
Middle_Initial; Person_middle_name_initial
Faculty_Code; Department_faculty_code
DEPARTMENT; DEPARTMENT object; SUBSET [Dept_Ltr_Code]
SEGMENT; SEGMENT object; MV; SUBSET [Segment_Number, Lect_Hrs, Lab_Hrs, Segment_Students, Day, Period]

ROOM OBJECT

Building; Room_building_location
Room_Number; Room_number_in_building

DEPARTMENT OBJECT

Dept_Ltr_Code; Department_letter_code

TABLE 4.7 INSTRUCTOR SCHEDULE CARD DOMAIN DEFINITIONS

All domain definitions are the same as those of the Master Instruction Schedule and Student Schedule Cards except for the following additional domain:

Person_first_name
    Text 10
    First name of a person

<u>(4) Classroom and Laboratory Schedule Cards.</u> Figure 4.8 shows a representation of a Classroom or Laboratory Schedule Card (see Appendix C for more detail). Figure 4.9 shows the Object Diagrams and Tables 4.8 and 4.9 show the Object Specifications for these room schedule cards.

```
 44
 _____________________________________  || ______________
 |    1  |   2  |   3  |   4  |   5   || |   8  |   9  |
 ------------------------------------- || ---------------
M|                 IS4185-1                  IS4185-2   |M
O|                 I-267                     I-267      |O
N|                 18                        20         |N
--------------------------------------------------------
T|                                                      |T

________________________________________________________
  I-267      *39 capacity   T (other info)    WINTER 92

* Classroom Schedule Cards show seating capacity;
  Laboratory Schedule Cards show the letter code of the
  department that usually schedules labs in the room,
  e.g., AS
```

Figure 4.8 Classroom or Laboratory Schedule Card

ROOM_CARD

Card_Number
Year
Quarter_Name

COURSE$_{MV}$

ROOM

Building
Room_Number
Capacity (Classroom cards only)
Arrangement
Features

COURSE

Course_Type
Course_Number

SEGMENT$_{MV}$

INSTRUCTOR

Last_Name

SEGMENT

Segment_Number
Day$_{MV}$
Period$_{MV}$

INSTRUCTOR$_{MV}$

ROOM$_{MV}$

DEPARTMENT
(Lab cards only)

Dept_Ltr_Code

Figure 4.9 Classroom or Laboratory Schedule Card Object Diagrams

TABLE 4.8 CLASSROOM OR LABORATORY SCHEDULE CARD OBJECT DEFINITIONS

ROOM_CARD OBJECT

Card_Number; Schedule_card_number
Year; Schedule_year
Quarter_Name; Schedule_quarter_name
COURSE; COURSE object; MV; SUBSET [Course_Type, Course_Number]

COURSE OBJECT

Course_Type; Course_type
Course_Number; Course_number_code
SEGMENT; SEGMENT object; MV; SUBSET [Segment_Number, Day, Period]

DEPARTMENT OBJECT

Dept_Ltr_Code; Department_letter_code

(continued on next page)

TABLE 4.8 CLASSROOM OR LABORATORY SCHEDULE CARD OBJECT DEFINITIONS (continued)

SEGMENT OBJECT

Segment_Number; Course_segment_number
Day; Academic_day; MV
Period; Academic_hour; MV
INSTRUCTOR; INSTRUCTOR object; MV; SUBSET [Last_Name]
ROOM; ROOM object; MV; SUBSET [Building, Room_Number]

INSTRUCTOR OBJECT

Last_Name; Person_last_name

ROOM OBJECT

Building; Room_building_location
Room_Number; Room_number_in_building
Capacity; Room_seating_capacity
Arrangement; Room_seating_arrangements
Features; Room_features_or_equipment

TABLE 4.9 CLASSROOM OR LABORATORY SCHEDULE CARD DOMAIN DEFINITIONS

Domains the same as in the Master Instruction Schedule or other schedule cards except these additional ones:

Room_features_or_equipment
    Text 20
    Description of features or equipment about a room that distinguish it from other rooms

Room_seating_capacity
    Numeric 3
    Number of chairs with table space or desks or standing room; functional student capacity

Room_seating_arrangements
    Text 1; Mask X
        where X is values T (tables and chairs) or D (desks)
    Seating arrangements for students taught in a room

c. SECT File

The SECT file of the Curricular Officer Database contains all the information needed to produce the Student Schedule Cards except for course credit hours, which are obtained from the On-Line Course Catalog database. The SECT file contains the same objects that are represented in the Student Schedule Cards and the other reports that are generated from it (e.g., Curricular Officer Report, Department Chairman Report). Although the structure and names may be different, the objects and their properties are immediately recognizable.

Figures 4.10 shows a representation of the structure of the SECT file [Ref.2]. Figures 4.11 shows the Object Diagrams and Tables 4.10 and 4.11, the Object Specifications for this file. Figure 4.12 shows how the Curricular Officer Report and Student Schedule Cards derive their information from the SECT file.

```
SECT.FOC
    |
SECTNUMB [CC,SECT]
    |
SECTCODE [SC,INDX,YEAR,QUARTER,NON,NOC,DEGREE,YRGRP]
|       |
|       SECTINFO [CNAME,SSN,RH,CCUR]
|
SECTCLAS [PCLASS,SEGM]

Note:  Some properties have abbreviated aliases, shown
       above. Full names are given in the Object Diagrams.
```

Figure 4.10 SECT File Structure

Objects in the SECT file can be compared with objects developed for the reports in the following manner:

- SECT.FOC is the object for the SECT file.
- SECTNUMB is similar to the object CURRIC_PROGRAM.
- SECTCODE is similar to the object SECTION.
- SECTINFO contains STUDENT properties found in the object STUDENT_CARD.
- SECTCLAS contains COURSE properties found in the object STUDENT_CARD.

<u>SECT.FOC</u>

SECTNUMB$_{MV}$

<u>SECTNUMB</u>

Ccurric
Csection$_{MV}$

SECTCODE$_{MV}$

<u>SECTCODE</u>

Sectcode
Indx
Quarter
Nonames
Noclasses
Degree
Yrgrp

SECTINFO$_{MV}$

SECTCLAS$_{MV}$

<u>SECTCLAS</u>

Pclass
Segment_No (blank)

<u>SECTINFO</u>

Cname
Cssn
Rhash_No (blank)
Curriculum

Figure 4.11 SECT File Object Diagrams

TABLE 4.10 SECT FILE OBJECT DEFINITIONS

<u>SECT.FOC OBJECT</u>

SECTNUMB; SECTNUMB object; MV

<u>SECTNUMB OBJECT</u>

Ccurric/CC; Curriculum_program_number_code
Csection/SECT;
Curriculum_letter_code_plus_section_number; MV

(continued on next page)

TABLE 4.10 SECT FILE OBJECT DEFINITIONS (continued)

SECTCODE OBJECT

Sectcode/SC; Curriculum_student_course_group_number
Indx; Schedule_card_number
Quarter; Schedule_quarter_number
Nonames/NON;
Curriculum_student_course_group_no_of_students
Noclasses/NOC;
Curriculum_student_course_group_no_of_courses
Degree; Curriculum_student_course_group_degree
Yrgrp; Curriculum_student_course_group_yeargroup
SECTINFO; SECTINFO object; MV
SECTCLAS; SECTCLAS object; MV

SECTCLAS OBJECT

Pclass; Course_type_plus_number_code
Segment_No/SEGM; Course_segment_number

SECTINFO OBJECT

Cname; Person's_last_name_first_and_middle_initials
Cssn/SSN; Person's_social_security_number
Rhash_No/RH; (remnant of old program - not used)
Curriculum/CCUR; Curriculum_program_letter_code

TABLE 4.11 SECT FILE DOMAIN DEFINITIONS

These domains are the same as described in the domain definitions for the Master Instruction Schedule and schedule cards:

Course_segment_number
Curriculum_program_letter_code
Curriculum_student_course_group_number
Curriculum_student_course_group_no_of_students
Schedule_card_number
Schedule_quarter_number

(continued on next page)

These domains are combinations of domains described for the Master Instruction Schedule and schedule cards:

```
Curriculum_letter_code_plus_section_number
    Text 4; mask AANN,
            where AA is curriculum_letter_code,
            NN is curriculum_section_number
    Combination of the letter code for a curriculum
       within a curricular program and the number code
       for the section within a curriculum

Course_type_plus_number_code
    Text 6, mask AANXXX,
            where AA is course_type, N is 0-4,
            XXX is course code
    Combination of a code for the course subject and a
       number code assigned to the course

Person_last_name_plus_first_and_middle_initials
    Text 15, Mask:
                  Person_last_name Text 13
                  Person_first_name_initial Text 1
                  Person_middle_name_initial Text 1
    Combination of the first thirteen letters of a
       person's last name, the first letter of a
       person's first name and the first letter of a
       person's middle name
```

These domains are new to the SECT file and have not yet been described.

```
Curriculum_number_code
    Numeric 3
    Number code for curriculum in a curricular program

Curriculum_program_number_code
    Numeric 2
    Number code for curriculum in a curricular program

Curriculum_student_course_group_degree
    Text 2
    Academic degree attainable by students in a student
       course group who complete their program of
       curriculum courses
```

(continued on the next page)

TABLE 4.11 SECT FILE DOMAIN DEFINITIONS (continued)

Curriculum_student_course_group_yeargroup
    Numeric, mask AB,
        where A is last numeral of schedule_year,
        B is schedule_quarter_number
    Quarter and year student course group is expected to complete their program of curriculum courses and graduate

Person's_social_security_number
    Numeric 9
    Social security number of a person

```
Curricular Officer Report:

SECT:     YEAR QUARTER  CC      SECT   SC    NOC      NON
             |    |      |       |      |     |        |
Report:   YR 92  2    CURRIC    SECT   SC  #CLASSES #NAMES

Example:               37       PL11   2      4        2

SECT:     PCLASS   SEGM          ***        ***
          |        |              |          |
Report:   CLASS    SEGMENT_NO    LECT_HR    LAB_HR

Example:  IS4185                  4          1

SECT:     CNAME       DEGREE    YRGRP
            |           |         |
Report:   CNAME       DEGREE    YGRP

Example:  NOLAN JS     MS        23
```

(continued on the next page)

Figure 4.12 SECT File Information Distribution

```
Student Course Group Schedule Card:

SECT:     INDX   SECT   SC   NON          CCUR   QUARTER YEAR
           |      |     |     |             |       |      |
Example:   218   PL11   2    2 Students    CT     Qtr 2   91-92

SECT:      PCLASS     SECT   SC    PCLASS   ***
             |          |     |      |      ||
Example:   IS 4185    PL11   2      IS418541

*** indicates information from the On-Line Course Catalog
```

Figure 4.12 SECT File Information Distribution (continued)

<u>d. On-Line Course Catalog</u>

A course's credit hours are obtained from this database. It is also the definitive source of courses offered by departments against which other files can be tested for erroneous entries, e.g., the process which results in the Exception Listing (see Chapter II). [Ref.2] and [Ref.4]

<u>e. Supplemental Databases</u>

In addition to information in the SECT file and the On-Line Course Catalog database used by all versions of NPS[4], the database component of the Initial Version would contain supplemental relational databases residing on the Class Schedulers' computer(s). These would be created by converting information on papers in Binder #1 into automated form. Most papers in Binder #1 contain information required to schedule

meetings and seminars (see Chapter III, Section D3d). Their titles and descriptions follow [Ref.4]:

- Meetings and Seminars Regularly Scheduled - the key paper, indicating when (and often where) the events represented on the other papers are to be scheduled.

- NPS Courses Requiring Secure Classrooms - courses in which classified military information is presented that need rooms that are not susceptible to the risk of external eavesdropping.

- ECE Lab Rooms - restrictions on combinations of Electrical and Computer Engineering Department courses and laboratories taught in Bullard Hall.

- Academic Council Membership - faculty membership in this group responsible for academic standards [Ref.1:p.19].

- Faculty Council/Faculty Officers Listing - faculty membership in the council serving as the primary faculty input vehicle to the Provost and Superintendent [Ref.1].

- ASW Academic Group Membership - membership of faculty from different departments responsible for overseeing the content of programs associated with Anti-Submarine Warfare.

- EW Academic Group Membership - membership of faculty from different departments responsible for overseeing the content of programs associated with Electronic Warfare.

- C3 Academic Group Membership - membership of faculty from different departments responsible for overseeing the content of programs associated with Command, Control and Communications.

- SSAG Membership - membership of faculty from different departments responsible for overseeing the content of programs associated with Space Systems.

The exact structure of the supplemental databases would have to be determined using the same methods detailed for the Master Instruction Schedule and schedule cards in previous subsections. A suggested way to convert this information into databases follows:

(1) Semi-Permanent Events and Courses Database. Derive this database from the paper "Meetings and Seminars Regularly Scheduled". Show the event or course designator (e.g., meetings, seminars and non-instructional courses), their associated required day, time period(s) and rooms, and a comment on where to find the participants. For example:

EVENT/COURSE	DAY	PERIOD(S)	ROOM	PARTICIPANTS
EW Group Mtg.	FRI	2	---	See EW Academic GroupMembership
IS 0001	THU	8-9	S-321	See AS Dept. Chairman Report

When combined with the following databases, this database could be the key to automatically scheduling the time periods and rooms for these events or courses on the schedule cards of all student and faculty participants.

(2) Departments and Faculty Database. Derive this database from the "Professor Listing by Department" report obtained by the Class Schedulers from the Registrar Database, as well as other information about departments and their faculty deemed useful to the Class Schedulers, e.g., offices and phone numbers for departments and faculty members.

From a database construction perspective, the Professor Listing report lists the DEPARTMENT object property Dept_Ltr_Code (e.g., AS for Administrative Sciences Dept.) and each department's faculty members. A new object, FACULTY,

would be used, which is the object INSTRUCTOR plus all faculty who are not teaching during the quarter being scheduled. The Professor Listing report lists the properties Faculty_Code, Last_Name and First_Name for each of its FACULTY.

This database could efficiently contain the membership information in most of the relevant papers in Binder #1 by indicating which faculty member is a member of each group. For example:

DEPARTMENT	CODE	FACULTY	CODE	AC	FC	EW	ASW	C3	SS
Admin.Sci.	AS	Hobbes, Calvin N	Hb	X	X				

This database would be used to provide information needed to construct Instructor Schedule Cards not found in the SECT file or On-Line Course Catalog. It would also be used to construct the faculty list at the back of the Master Instruction Schedule. When used in conjunction with the Semi-Permanent Events and Courses Database, NPS[4] could automatically schedule these events on the Instructor and Regular Classroom Schedule Cards.

(3) Classroom Database. Derive this database from information contained on the Regular Classroom and Laboratory Schedule Cards in the file in the Class Schedulers' office. This database would essentially be an automated set of Classroom and Laboratory Schedule Cards and would be used to automate these cards. It would also be used in scheduling

courses by searching it to locate a set of all rooms with the right seating capacity or features for the course being scheduled. For example:

BUILDING	ROOM	CAPACITY	ARRANGEMENT	FEATURES	COURSES
Ingersoll	267	39	T	---	---

(4) Other Supplemental Databases. Other databases that could be useful to the Class Schedulers, though not as necessary as the aforementioned are:

- Curriculum Database. Similar to the Departments and Faculty Database, this database could contain information on curricular programs, their curricula, current sections and even a curriculum course matrix for the curriculum. It could also contain information on Curricular Officers such as office and phone numbers.

- Course Database. Instead of having to access a small portion of On-Line Course Catalog, this database could contain course credit hour information and could check automatically against the On-Line Course Catalog before use. It could also contain information about what rooms or building floors would be acceptable for each course, which could be incorporated into NPS^4 as a "memory aid" to the Class Schedulers when selecting rooms for courses.

2. Extracting Mainframe Information

The exact method by which information would be extracted from the mainframe files and stored in the Class Schedulers' office computer(s) for NPS^4 use will have to be determined when the exact hardware and software specifications of NPS^4 are determined. A suggested method would be:

- STEP #1 - make copies of the SECT file and On-Line Course Catalog database and transfer these copies into the Class Schedulers' mainframe account. This would provide NPS^4 with the information it needs, allow NPS^4 to operate

independently of the present system and provide security to the existing files. This step could be incorporated into the Pre-Scheduling memorandum.

- STEP #2 - access the database copies in the Class Scheduler's mainframe account via the TELNET function of the MIS Network (see Section B).

- STEP #3 - import the information in the copied files into an NPS[4]-compatible database. It may also be possible, and maybe easier, to import the information into the personal computer version of FOCUS.

- STEP #4 - use a utility program to aid in extracting database information into and out of NPS[4] files via the TELNET function of the MIS Network. If HyperCard is the chosen user interface program, a compatible utility program such as HyperPort[11] could assist in creating NPS[4] HyperCard stacks[12].

E. SCHEDULING MODEL

1. NPSS

The Naval Postgraduate School Scheduler (NPSS) program is a mathematical model of the NPS scheduling process developed in Pascal VS by NPS Professor Erickson in 1990. NPSS uses the SECT file as its primary input data to construct a complete quarterly schedule for the regular 11 weeks of instruction. Resident on the NPS mainframe, it has been

[11] HyperPort is a HyperCard utility program available from Concentrix Technology, Inc. that simplifies text transfers into and out of HyperCard stacks, particularly complex transfers of multiple database fields.

[12] A "stack" in the HyperCard program is a separate file. The HyperCard program organizes data in stacks, which have one or more "cards" (which appear to the user as different screens on the computer monitor), each of which has a non-changing "background" and changeable text "fields" and graphical "buttons". [Ref.37:p.27]

tested numerous times with successful results between 1987-1990 using actual scheduling data from the Spring quarter of AY 1987. [Ref.26]

NPSS uses a stochastic approach to finding an optimal scheduling solution by introducing a probabilistic component into a preliminary solution, recalculating and examining the results to determine if a better solution was reached. The process tends towards a minimum conflict solution, avoiding early local optima by allowing occasional uphill moves. This process is referred to as "simulated annealing", because it is similar to metallurgical annealing, whereby a piece of metal is reheated and slowly cooled to allow its molecular structure to achieve a minimal energy state. Figure 4.13 shows a representation of this process.

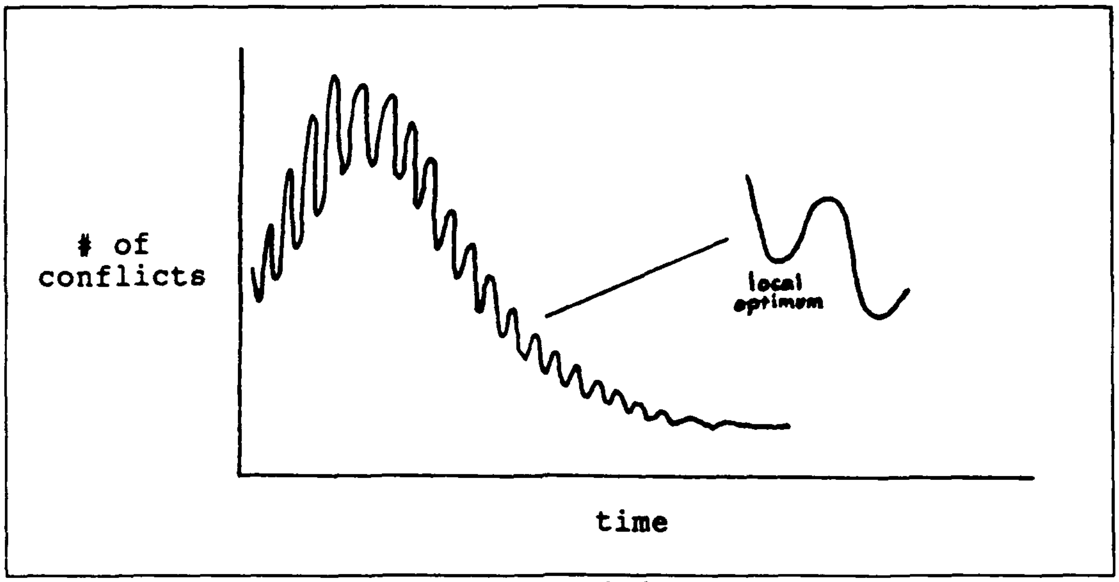

Figure 4.13 NPSS Optimization Process

In addition to the SECT file, NPSS gets its required information from manual inputs of instructor assignments and any constraints from the third iteration of the Department Chairman Report. Room equivalence data is also manually entered, i.e., rooms are entered with their seating capacity and any distinguishing features so that NPSS can determine sets of rooms that will suffice for courses. The user may also specify weighting factors to apply to situations, e.g., scheduling convention rules, so NPSS can resolve conflicts.

In its present state, NPSS can either create a rapid trial schedule using a "greedy" parameterized heuristic search or a more thorough schedule using a completely parameterized stochastic search, i.e., using the described stochastic method taking into account all manual entries.

One measure of how well NPSS can create a schedule is the number of student conflict hours that remain in its solution (see Section A1c for an explanation). From an estimated initial 40,000 potential student conflict hours, NPSS is able to arrive at a schedule with about 100 student conflict hours remaining (99.75% conflict-free), depending on the amount of computer time expended to the problem. By comparison, the final set of Student Schedule Cards for the Winter quarter of AY 1992 had 122 remaining student conflict hours, after another 100 were resolved by phone calls. Figure 4.14 shows the number of student conflict hours remaining in solutions for various amounts of applied computer time when

NPSS was tested on the NPS mainframe (an IBM 3033 at the time) in 1990.

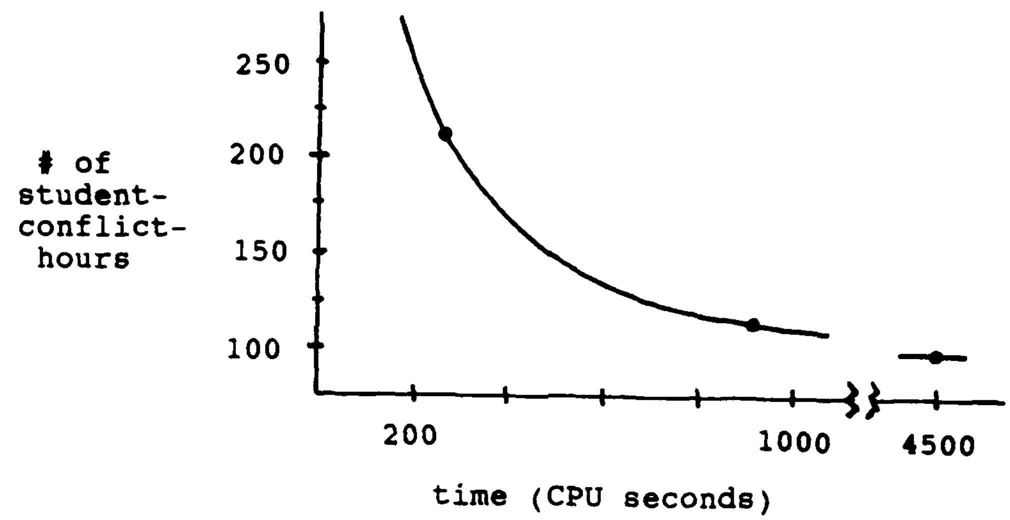

Figure 4.14 NPSS Performance

NPSS could serve as the problem modelling component of NPS[4] to assist the Class Scheduler in making decisions regarding selection of time periods and rooms. Future planned improvements and suggestions for implementing this model into NPS[4] and the scheduling process are presented in Chapter V.

2. Final Exam Scheduler

Dietmar Fiegas developed a final exam scheduler written in PL1 that yielded successful results when applied to actual scheduling data of the Winter quarter of AY 1985. It consists of two programs, one to prepare the data and the other to execute the final exam scheduling program. Its run time was 90-120 CPU-seconds on the NPS mainframe (IBM 3033).

This set of programs might be able to be incorporated into NPS^4 with further investigation and testing. See Reference 19 for details and the program code. [Ref.19:p.33-53,88,90-123]

F. PRESENTATION SYSTEM

As mentioned earlier in this chapter, NPS^4 in its initial stages would be transparent to all parties involved in the scheduling process except for the Class Scheduler. Therefore, all reports familiar to these parties would have to be continued for the time being. However, NPS^4 could replace the present reports needed by the Class Schedulers when value-added information becomes available through NPS^4.

One example where NPS^4 could be of assistance as a report generator is in generating an E-Z Class Demand Listing with the information already printed on it which the Class Schedulers write in manually under the present system. NPS^4 would also have the information contained in the Department Chairman Report. Figure 4.16 shows representations of the Department Chairman Report and the E-Z Class Demand Listing before and after the information is added by the Class Schedulers. NPS^4 could also generate the Pre-Scheduling Memorandum and the Dates for Operations sheet, since the dates indicated for actions or events in both are the same relative to each quarter. These applications would require entering information about quarter starting and ending dates, and a date calculating algorithm.

Department Chairman Report:

origin:	YEAR	QUARTER	Unk.	PCLASS	Calc1	***	***
report:	YEAR	QUARTER	DEPT	CLASS	#TOT	LECT	LAB
example:	92	3	AS	IS4185	18	4	1

origin:	SECT	Calc2	CNAME	Manual		Manual	Manual
report:	SECT	#STU	[Names]	SEGMENTS		PROFESSOR	ROOM
example:	PL11	2	NOLAN,JS	2	AS/Hb	HOBBES	I-267

E-Z Class Demand Listing: (before)

origin:	Unk.	PCLASS	Calc2	***	***	(SEGM)
report:	DEPT	CLASS	#STU	LECT	LAB	SECT
example:	AS	IS4185	18	4	1	blank

E-Z Class Demand Listing: (after)

origin:	Unk.	Manual	PCLASS	Manual	Calc2
report:	DEPT	PROF	CLASS	STATUS	#STU
example:	AS	HG	IS4185	X	18

origin:	***	***	Manual	Manual
report:	LECT	LAB	SECT	COMMENTS
example:	4	1	2	no final, prefer after 1000

(continued on next page)

Figure 4.15 Department Chairman Report and E-Z Class Demand Listing Structures

Legend for Figure 4.15:

```
***......from On-Line Course Catalog database or
         supplemental COURSE Database
Calc1....calculated from adding the number of CNAMEs
         for each PCLASS
Calc2....calculated from adding the number of CNAMES
         for each SECT associated with this PCLASS
Manual...manual entries by Class Scheduler from the
         third iteration of the Department Chairman
         Reports; SECT is SEGM, the number of course
         segments; STATUS is checkmarks used by the
         Class Schedulers to monitor the status of
         the scheduling of a course
Unk......unknown origin; likely a manual entry;
         in NPS4 this could come from the Departments
         and Faculty Database
```

Figure 4.15 Department Chairman Report and
E-Z Class Demand Listing Structures (continued)

G. USER INTERFACE

HyperCard and Toolbook are both recommended programs to use to develop NPS[4]'s user interface because of the way it handles information. Their method of data organization, a concept is called "hypertext"[14], enables a user to select a data element and jump from that element to any other element related to it. This concept is the technology by which data is stored and made available for access in both programs. [Ref.37} and [Ref.38]

[14] The term "hypertext" was coined in the mid-1960s by Ted Nelson to describe the idea of linking information threads for data retrieval systems [Ref.37:p.5].

NPS scheduling is not a standardized methodical process whereby the Class Schedulers go from one set of data to the next in the same order each time. While there are logical steps to the process, the Class Schedulers have to jump from report to report, from locating course information to locating all students taking that course, to an instructor, to requirements or preferences for the course, to other courses the instructor and students may have. While each of these items is related to each other, there is no way to design a database or other information handling device that could keep the information in the order in which the Class Scheduler needs it because the order changes all the time.

Both programs have unique scripting languages[15] that enable developers and knowledgeable users to modify their programs rapidly, even when stopped in the middle of a program ([Ref.37] and [Ref.39]). Another valuable feature for is that much of an application can be initially written or modified using a graphical interface that contains a built-in code generator, i.e., a software designer or the user can customize features of a program without having to know any of the programming language. Program screens (called "cards" in Hypercard and "pages" in Toolbook) can be customized with a drawing and painting option, text fields can be added in many

[15] HyperCard's language is called HyperTalk. Toolbook's language is called Openscript. Both are "high level" (near English) scripting languages with similar appearances.

fonts, and buttons can be added that, when selected, jump to other data, or to another screen. These features and others can be created thrcugh the graphical design interface without knowing the scripting language. With a little knowledge of the language, a user can transfer and manipulate data easily and sophisticated programs can be written by persons with little programming skill.

The HyperCard 2.0 Handbook has this to say about the scripting language HyperTalk:

> The language was painstakingly designed to be easy to learn and use. The goal was to put powerful authoring tools into the nontechnical hands of those who need custom applications that no commercial developer would dream of. The HyperCard environment puts programming into the hands of specialists in areas other than computers.... [Ref.37:p.316]

HyperCard is also a compatible front end user interface application for accessing data on mainframe computers:

> Increasingly, HyperCard is also becoming the software 'glue' between Macintoshes and mainframe computers. Easy-to-use HyperCard-based applications can provide friendly access to otherwise complex databases, electronic mail systems, and group software running on IBM, DEC, Tandem and other mainframes. [Ref.37:p.11-12]

Toolbook has much the same characteristics as HyperCard, plus having the added feature of color, and could be employed equally well to develop a user interface for NPS[4]. [Ref.38] and [Ref.39]

H. DEVELOPING NPS^4

NPS^4 could make scheduling duties for the Class Scheduler easier and more efficient. While not eliminating the human element, NPS^4 could eliminate the redundant labor of having to manually write and erase course schedules and manually sort and locate physical schedule cards. NPS^4 could act as a memory aid device, conflict detector and options location tool to aid Class Schedulers in constructing quarterly schedules.

In addition to the implementation described, there are other ways that the concept of NPS^4 can be retained, but with different components or equipment. Chapter V analyzes alternative approaches to developing and implementing NPS^4, such as how to actually develop the system and where it fits into the whole scheduling process. The chapter further describes how NPS^4 could be expanded to include more of the scheduling process and what potential problems might be encountered in implementing the DSS into the ongoing process and the NPS environment.

V. APPROACHES TO NPS^4 DEVELOPMENT AND IMPLEMENTATION

Chapter IV describes advantages Class Schedulers would have using NPS^4 instead of the present system, and discusses possible ways that NPS^4 could work. This chapter examines the likely benefits and costs of development alternatives and presents considerations concerning implementation of NPS^4.

A. THE MOST IMPORTANT CONSIDERATIONS

The most important consideration at the onset in preparing the NPS^4 concept for design development is to ensure that the requirements and specifications are thorough and correct. Chapter III, which has been reviewed by the Class Schedulers and the Management Analyst and validated by them as being accurate, details the present scheduling system so future developers can understand the requisite functionality of NPS^4. Chapter IV describes the concept of NPS^4 and provides high-level specifications for the project and its components. Chapter V analyzes development alternatives and implementation considerations. The NPS^4 concept must be thorough and correct during these stages before design work can be attempted.

In designing NPS^4, developers should attempt to address the most pressing concerns of the Class Schedulers about the present process:

- Constantly having to locate, retrieve, and replace physical schedule cards for each scheduled course.

- Lack of standardization in department entries to the third iteration of the Department Chairman Report; ambiguity over whether rooms and time periods indicated are actually required or just preferred.

- Lack of a method to properly document the time, person and change to the schedule during the Post-Scheduling phase.

NPS[4] addresses the first concern by creating electronic cards that are automatically located, retrieved and replaced during course scheduling. The Prototype and Initial Versions don't yet address the lack of standardization of Department Chairman Report entries. One solution is to automate the entries by using a standardized questionnaire, either automated or unautomated, that is worded to eliminate the ambiguity. An example of a possible constraint questionnaire and the code for an automated version of it were both developed by Fiegas [Ref.19:p.27-28,124-133]. NPS[4], by creating electronic schedule cards, could address the third concern by providing a checkbox on each schedule card that, when selected, would present a dialog box requesting a name and the change (time/date would be added automatically). The box would provide room for free-text comments and be stored associated with the card. The change can be made to the card by NPS[4] in another style or font for easy recognition.

B. DEVELOPMENT ALTERNATIVES

1. Maintaining the Status Quo

Maintaining the present system is an option. However, it was argued in Chapter IV that conditions have changed so that scheduling at NPS has stressed the present system to its limit. These same conditions are likely to continue to increase the labor required to construct quarterly schedules.

The benefits of maintaining the status quo are that it works, everyone involved is familiar with the process and it would not require any extra resources for the near future. The existing system is reliable and maintainable.

Some foreseeable costs to maintaining the present system are increasing personal energy expenditures, limited flexibility and limited expandability. The largest cost though, as scheduling increasingly takes more effort, is likely to be personnel costs in terms of paying the Class Schedulers for overtime (as was the case in the current Spring quarter of AY 1992), or having to locate other personnel to assist in completing the schedules in the required time.

2. Reuse of Software or Sharing Resources

This is not a valid option. NPS scheduling is a unique process (see Chapter III, Section A5) that can not be adequately accomplished by reuse or sharing of any known program presently in operation by other federal agencies. Likewise, there are no known software packages that could be

used off the shelf or even substantially modified to adequately automate the present scheduling process.

3. Contracting Services

This would be an expensive option requiring significant training of contract personnel. Class Schedulers have typically apprenticed for up to five years with the previous Class Schedulers before scheduling on their own. Likewise, contracting out the development of NPS^4 may be more costly than justified by the size of the project and benefits it would likely provide.

4. In-House Development

The Naval Postgraduate School abounds with students, faculty and MIS personnel with the expertise and talent to develop NPS^4 in-house.

5. Reconfiguring the System

The intended application of NPS^4 would apply to a currently unautomated process, so reconfiguring the system at this stage is a moot option. Likewise, "reconfiguring" the manual process is not a valid option. The Scheduling phase process has been honed over the last 25 years to be as efficient as possible.

Rethinking the system from a personal computer versus a mainframe perspective needs to be assessed. While the Forecast and Scheduling Programs may benefit from the storage space and speed the mainframe provides, a personal computer

LAN may serve the Curricular Officers, departments, Class Schedulers and others involved in the scheduling process as well as hard-wired mainframe terminals. Personal computers may also provide greater flexibility to manipulate and use data and to support more "user-friendly" interfaces than the present FOCUS language system provides.

6. Augmenting the System

NPS^4 takes this approach. The Naval Postgraduate School Scheduling Support System DSS is intended to take advantage of the present system, while augmenting it with a powerful decision-making tool for the Class Schedulers. Augmentation of parts of the system is probably the most viable option in terms of holding down costs of implementation and ease of transition into a new system.

7. Replacing All or Part of the System

NPS^4 requires replacing part of the present system. The Class Schedulers' office personal computer would need to be replaced or upgraded by one computer with keyboards and screens for both Class Schedulers, and possibly a time-sharing capability, or by two separate computer systems. In the Initial Version of NPS^4, the Schedule Card Program, and its end-product Student Schedule Cards, would no longer be needed. Likewise, some of the applications such as the E-Z Class Demand Listing and the Master Instruction Schedule report generation program could be assumed by NPS^4.

8. Assessment of Development Alternatives

a. Resources

(1) People. To maintain the status quo, an additional Class Scheduler might have to be acquired and trained under the present Class Schedulers. However, there is limited space now in the present Class Schedulers' office, and training an additional person (the second Class Scheduler has only been working on schedules for two quarters) would be more work for the head Class Scheduler, who has to work overtime this quarter as it was.

If scheduling were contracted out, it could not be assumed that contract personnel could schedule any faster or more efficiently, or that it would require less people than are presently scheduling. Further, an extensive training period on the order of years might be required. Contracting NPS^4 development does not appear to be a desirable alternative to developing the DSS in-house at NPS.

NPS students, faculty members or MIS personnel could develop NPS^4. Eventually MIS personnel must be involved to successfully implement the project and to ensure its continued maintainability. MIS personnel should be involved early in the development, if even only from an advisory standpoint, in order to incorporate NPS^4 into the overall MIS plan for the school.

Students could develop the initial stages of NPS[4] as part of a follow-on thesis or as a course project. A group of students could develop NPS[4] as part of a cooperative software development course project or as a number of related theses, much like other complex projects have been subdivided. Faculty members could develop the project during a research quarter if funding were provided. MIS personnel could also develop NPS[4] from the beginning, assuming they had time to devote to this project. Regardless of the development path, the Class Schedulers must be involved throughout the project to validate its accuracy and usefulness.

Reconfiguring or replacing parts of the present system would require a number of personnel, particularly if LANs were installed where they don't now exist. However, that option would not be needed if NPS[4] were expanded to include phases of the scheduling process other than the Scheduling and Post-Scheduling phases. Replacing the personal computer in the Class Schedulers' office would require a trained technician, since it would have to connected to the MIS LAN.

(2) Hardware. Hardware changes for the proposed Initial Version of NPS[4] are small - a new personal computer or computers for the Class Schedulers' office with monitors and keyboards for both Class Schedulers. If either HyperCard or Toolbook were selected as the user interface tool, NPS[4] could be developed on an Apple Macintosh or IBM-compatible in

Spanagel Hall that belong to the Computer Science Department, or on a new machine in the Class Schedulers' office. The latter choice would serve three purposes:

- No additional computers would be needed in the development process.
- NPS[4] would definitely be compatible on the Class Schedulers' office computer.
- The developer would have ready access to the Class Schedulers to validate development steps.

Expanded versions of NPS[4] could be run off the mainframe with no added hardware required, if it were written in a compatible language, or hard-wired terminals could be replaced with a LAN connecting the personal computers found in virtually every office on campus.

<u>(3) Software.</u> The software development programs mentioned in Chapter IV already exist at NPS on computers in Spanagel Hall, except for some HyperCard utility programs. A site license might have to be obtained or extended to use them in the Class Schedulers' office. HyperCard already comes installed on Apple Macintosh computers. NPS[4] could be developed completely with these development tools. Necessary utility programs would have to be purchased to fully implement the program.

Contracting out the project would involve whatever software was used or developed by contractors. Life cycle management techniques would have to employed, as with any software development project. The software development

effort would most likely have to meet federal ADP acquisition procedures and software development standards and guidelines, since NPS is a federal institution.

(4) Funding. If NPS[4] is developed by students or faculty as part of their general course of research, no additional funding might be required in the early stages of development other than expenditures normally incurred in thesis, course or research projects. Funding would be required if NPS[4] were developed by faculty during a research quarter. Funds would also be required for a new personal computer or computers in the Class Schedulers' office, for software (except HyperCard) to support NPS[4], and to implement, maintain and possibly expand the project.

(5) Time. Since the present system works, time is not a critical factor. However, the Class Schedulers are working at peak capacity now. Developing, testing and installing NPS[4] now would avert potential problems that could be encountered in the near future.

Estimates of the amount of time required to develop NPS[4] depend on the personnel and effort applied. A reasonable estimate for having a workable Prototype Version, if developed by two students in a follow-on thesis is two quarters, if appropriate support were provided.[16] The development process is highly dependent on the events of the

[16] See Section G for a discussion of this consideration.

NPS quarter. During the first of these two quarters, the students would develop the user interface from the information in this thesis and by observing the Class Schedulers. The students could rely on user input to validate each step in the development. However, the Class Schedulers would only be available to assist in the development process during the first four weeks of each quarter, and part of the last two weeks of the quarter. During the second quarter, the students could test out their developed system in parallel with the Class Schedulers. During the second quarter, the students would also have to train the Class Schedulers on the developed project. If faculty members or MIS personnel were also involved during the first quarter of development, the project might be completed in one quarter, but taking only one quarter to develop and test the project and to train the Class Schedulers is probably unreasonable.

The time required to develop the Initial Version of NPS^4 might be three to four quarters if developed by two students doing a joint thesis, and two to three quarters if more students, faculty and/or MIS personnel were involved. This accounts for time to incorporate NPSS into NPS^4 and to train Class Schedulers to use NPS^4 exclusively for schedule cards, rather than in parallel with the present physical schedule cards, as in the Prototype Version.

Estimates of the time required for a contractor to take over scheduling duties or for a contractor to deliver the

required software would most likely be much longer than for in-house development by students, faculty or MIS due to training and federal procedures requirements.

(6) Paper. Eliminating physical schedule cards, and possibly the Master Instruction Schedule (see next subsection), could save tens of thousands of pages of paper each quarter that are now used to print duplicate reports. Later versions of NPS[4] might eliminate the need for physical Curricular Officer and Department Chairman Reports, although these would be retained electronically (see Chapter VI).[17]

b. Interfaces

(1) Electronic Interfaces.

In the present system, the Class Schedulers use computer terminals connected directly to the mainframe, and a personal computer connected to the mainframe via a LAN. If the Class Schedulers' computer is upgraded to other IBM-compatible computers, the same interface that connects the existing one to the LAN should work for the new computers. If the office computer is replaced with Apple Macintoshes, the computers could connect to a 3174 Controller and then to the mainframe using an Avatar MacMainFrame or DCA MacIRMA Coax Board [Ref.37:p.726-727]. These are plug-in boards that

[17] Mike Troian, the Management Analyst, estimates that he prints out over 900,000 lines of text in support of each quarter's scheduling process.

enable the Macintosh to emulate the 3270-type terminals used by the Class Schedulers and Curricular Officers.

Since both Class Schedulers schedule at the same time, either a single computer with two keyboards and monitors, or two computers with separate keyboards and monitors would be required.

If the project is contracted out, interfaces between whatever hardware the contractor would be using and the NPS mainframe would have to be investigated.

(2) Software Interfaces. A software interface would have to be developed that would transfer information from a copied SECT file in the Class Schedulers' mainframe account into the selected NPS^4 database. The an IBM-compatible computer were selected, the existing system could be used to transfer data in and out of the mainframe. If HyperCard were selected, Applications Programming Interface (API) software[18] could be used to enable the Macintosh to display mainframe data on its screens [Ref.37:p.727]. The same software could be used to transfer an NPS^4-constructed Master Instruction Schedule from Macintosh to the mainframe.

Another software interface that needs to be developed is an interface between NPSS, written in PascalVS, and NPS^4. Toolbook contains tools to interface with other languages. HyperCard may likely contain these same tools.

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[18] APIs are XCMDs available through ~ .icentrix Technology, Inc.

For both Class Schedulers to schedule at the same time, either both could have separate copies of NPS[4] running on separate machines, and a method of data sharing between machines would have to be developed, or one program could run and a method established for time-sharing between both keyboards. Even though scheduling is usually divided between the Class Schedulers by departments, many student course groups take courses from more than one department. To prevent conflicts between Class Schedulers, data sharing by frequent floppy disk transfers or direct data transfer by LAN between the two machines[19] would have to be established.

(3) Personnel Interfaces. In addition to electronic and software interfaces, interfaces between NPS[4] and the user, and other affected persons must be considered. The Class Schedulers don't need physical cards or a Master Instruction Schedule. Both the Scheduling phase and Post-Scheduling phase can be performed easier and more efficiently with an electronic schedule and cards. However, if physical schedule cards, and possibly the Master Instruction Schedule, were eliminated in the Initial Version of NPS[4], how do students, instructors, departments, Curricular Officers and the Registrar get copies and how are copies of the schedule cards placed outside instructor offices and classrooms? Possible answers are:

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[19] For example, Netway by Tri-Data Corporation.

- PRINT SCHEDULE CARDS AND THE MASTER INSTRUCTION SCHEDULE FROM NPS[4]. The purpose of automating schedule cards is to eliminate the need to laboriously write in (or erase) courses on all applicable schedule cards and to have a recognizable display medium to show Class Schedulers where courses could be scheduled or alert them to conflict situations. Once that purpose is served and the final schedule has been constructed, the disposition of the cards and the master schedule is determined by how personnel other than the Class Schedulers use the schedule. It would be necessary to retain a copy of at least the Master Instruction Schedule on the computer so the Class Schedulers could make changes to the schedule and document the changes during the Post-Scheduling phase.

- TRANSFER INFORMATION TO OTHER COMPUTERS. The Registrar, departments and Curricular Officers probably don't need physical copies of either the Master Instruction Schedule or schedule cards. However, they do use information on both of these. If the Master Instruction Schedule and card information could be sent to the mainframe for access by terminals or to personal computers in the offices of interested parties, the information could not only be used as the parties see fit, it could be accessed, searched, sorted, divided or printed out in whatever form, format or medium they found useful. They could print out whatever copies are needed for students, instructors or rooms.

- STORE INFORMATION ON FLOPPY DISKS. In lieu of sending Master Instruction Schedule and schedule card information to the mainframe, which may not be accessible by all departments, their information could be stored on either 3 1/2" or 5 1/4" floppy disks in a format readable on IBM-compatible personal computers, since this type is found in most NPS offices. Disk copies could be distributed to authorized parties, where they could be used as they liked, e.g., to print copies of the schedule for students, instructors or rooms.

- SEND STUDENT AND INSTRUCTOR SCHEDULES TO THEIR MAINFRAME ACCOUNTS. Instead of sending scheduling information just to the mainframe, send individual schedules to their accounts. Since account numbers are known and instructors and students can be associated with schedule cards, individual schedules could be electronically sent to their mainframe accounts. They could also be given read only access to the Master Instruction Schedule the same way that they have with the On-Line Course Catalog.

c. Feasibility and Desirability

The proposed NPS⁴ program is entirely feasible with existing technology and expertise found at NPS. The project can be developed and implemented in a reasonable amount of time at an acceptable cost in manpower and money. NPS⁴, as an add-on system, can be incorporated into the continuous-process system without an interruption and without taking the Class Schedulers away from their duties. Class Schedulers can learn at their own pace, and use a Prototype Version to assist in scheduling as few or as many schedule cards as desired. NPS⁴ could save enough time, even during training, to allow the Class Schedulers to both perform their duties and learn the new system. NPS⁴ would be transparent to all others in the scheduling process until further options are implemented.

The described concept of NPS⁴ is desirable to the Class Schedulers. They are enthusiastic about the possibility of eliminating the present need for constantly locating and replacing physical schedule cards and for having to write (and erase) courses manually on all associated cards.

C. DATABASES

Relational databases are needed to store information on students, courses and student course requests. There are several possible means of storing this information.

NPS⁴'s database(s) could store:

- All available information imported from the actual SECT file and On-Line Course Catalog database, plus information from papers in Binder #1, or any part of these three sources. Although the Initial—Version of NPS^4 would contain all this information, developmental versions would not need to. Some scheduling information can still be obtained from existing sources.

- Actual information from the SECT file, but read from the copied file and typed into the database, not imported electronically. This option can be used before the interface is developed.

- Actual information from the SECT file, either imported electronically or typed from the copied file. All the information in the SECT file is necessary to create an actual schedule, but not to develop NPS^4 or to demonstrate how NPS^4 works. Only a few courses are needed to develop or demonstrate the project, although they should contain all possible course circumstances such as segments, multiple rooms, time periods and instructors, a final exam, separate hours, etc.

- Actual information from the SECT file, but not necessarily from the current SECT file. Any SECT file will suffice for development purposes. Using an old SECT file for a quarter that has already been scheduled is advantageous because the developer can check NPS^4-created schedule cards, recommendations and schedules against those actually created by the Class Schedulers for that quarter.

- Simulated information in the same format as the SECT file. To develop NPS^4, it is not necessary to have actual data so long as the stored information represents realistic situations.

The following subsections present options for final or developmental NPS^4 database component software and media. One or more of the options can be used for prototypes before a final version of NPS^4 is developed.

1. HyperCard or Toolbook Database

The HyperCard or Toolbook programs can handle database functions using global variables, but may need a dedicated

database to store large amounts of information. For example, the user interface can store all the information from the papers in Binder #1, while using a dedicated database program to store schedule card information.

2. Dedicated Database

A dedicated database program compatible with either an IBM-compatible or Apple Macintosh can be used in conjunction with a Toolbook or HyperCard user interface. Toolbook or HyperCard are capable of performing database storage and management functions for hundreds of records acceptably, but the thousands of records that may be required for the NPS scheduling system would be more efficiently handled with a dedicated database, such as dBASEIV or HyperHIT, accessed from a front end user interface. [Ref.37:p.774] and [Ref.38]

3. FOCUS and a Personal Computer Database

Since databases and a database manager already exist on the mainframe, information can remain there and be accessed as needed. Unless the software that extracts the information from the mainframe is very fast, or NPS[4] is resident on the mainframe instead of a personal computer, this option might be too slow because of demanding information retrieval and updating requirements to refresh multiple schedule cards.

Mainframe scheduling files don't presently store instructor or room information, since these are manual entries to the third iteration of the Department Chairman Report.

Instructor and room information, as well as the information contained in Binder #1, would have to contained in personal computer databases or their mainframe counterparts.

4. The FOCUS System

FOCUS is the present database system and can be used either on the mainframe or a personal computer (NPS has a version of PC FOCUS) to store scheduling information. Additional databases may need to be created to store information the present databases don't. These supplementary databases can be stored on the mainframe with the existing databases, stored on the Class Schedulers' office computer(s) and the existing databases left on the mainframe, or stored on the office computer(s) along with the supplementary databases.

5. Assessment of Database Alternatives

The choice of database should be based on its intended use by the user interface, not the user interface chosen to fit the database. There is probably too much information required by NPS[4] to store it all in a HyperCard or Toolbook application, so a dedicated database is required. The most important information to be stored is the SECT file and any supplementary information needed to construct the electronic versions of the schedule cards for students, i.e., information on instructors and rooms. The information in these cards must be constantly retrieved and returned or updated in the process of scheduling courses and must be quickly rapidly via

the user interface. Although the Class Schedulers can assist NPS^4 by filling in missing information on the instructor and room schedule cards that is not in the SECT file, this is not desirable.

It is not imperative that other information be automated, but information that would be stored in the proposed supplementary databases provides NPS^4 with its potential to act as a true DSS, pointing out selection options to the Class Schedulers and alerting them to problems. This information need not be as quickly accessible by the NPS^4 user interface program.

In summary, if the user interface program has a way of storing the schedule card information, such as in HyperCard's or Toolbook's hypertext conventions, the SECT file and information required to construct the electronic schedule cards can be stored on either the mainframe or a personal computer in any program that is compatible with the user interface program. If the user interface can not store the information itself, then the information needed to construct the cards must be stored where it can be rapidly accessible to the user interface, presumably on the same computer as the NPS^4 program. Other supplementary information can be stored anywhere that it can be accessed by NPS^4, even remotely.

D. PROBLEM MODELS

1. NPSS

The Naval Postgraduate School Scheduler by Professor Erickson is the only problem model known to successfully simulate the NPS scheduling process problem. Although NPSS does not presently schedule rooms or final exams, this functionality can be added.

a. Integrated Mode

The Class Schedulers can use NPSS in a fully integrated mode with NPS^4, entering the requisite data, turning NPSS on, and waiting for a schedule to appear. The Class Schedulers need only to resolve remaining conflicts, using NPS^4, to arrive at a final schedule.

With expanded interactive capabilities added to NPSS, the Class Schedulers can enter weights to different model parameters to reflect scheduling conventions and fix known time periods or rooms to reflect requirements or preferences. After NPSS is run, the schedule solution can be inspected, desirable portions frozen, and NPSS run again to get a different solution for the other parts of the schedule.

b. Independent Mode

In a more independent mode, NPSS's output schedule can be used as a possible solution against which Class Schedulers can compare their independently created schedule, its schedule solution for each course can be used as default

selections, or NPSS can be used as a tool to explore ways a course might be scheduled ("what if" scenarios). Some ways to implement these ideas are:

- Print out the NPSS schedule solution.
- Show the NPSS schedule solution for a particular course on the NPS^4 screen as a selectable option by the user.
- Have the NPSS solution for a particular course schedule be in the background in grey and allow the user to select its solution as a default or to overwrite it with a schedule of their own.
- Use NPSS as part automated scheduler and part schedule collection tool, i.e., the Class Schedulers can schedule some courses, freeze them, allow NPSS to schedule others, freeze them, and continue swapping scheduling duties.

2. Final Exam Model

Fiegas's final exam model can be employed in NPS^4, but interfaces between its PL1 programs and NPS^4 would have to be written, as well as configuring the data needed by its data ordering program. Fiegas' programs might also be converted to something useable by NPS^4 or ideas from the program used when scheduling final exams in NPS^4. [Ref.19]

3. The Class Schedulers

The key to the NPS^4 decision support system is the accumulative knowledge and experience of the Class Schedulers. Models may be able to assist them with obvious or expected scheduling situations, but it is the Class Schedulers alone who can make the necessary decisions when things don't go as expected and when conflicts have to be resolved. The Class

Schedulers' heuristics will remain the primary problem modelling system used by NPS[4].

4. Assessment of Problem Model Alternatives

The Class Schedulers' knowledge should be the primary problem model, and the only one really needed by NPS[4]. However, many scheduling situations are routine and a problem model may prove useful to alleviate routine functions and give them time to work on more difficult scheduling situations.

NPSS can be used as an effective tool for tasks ranging from helping Class Schedulers make decisions for courses of action in "what if" scenarios, to constructing the entire schedule in the case of an emergency where one or the other of the Class Schedulers were unable to perform their duties, or scheduling information was destroyed.

Although some interfaces and redesign work would be necessary, Fiegas' final exam scheduling programs might also prove useful and should be considered as a possible problem model. [Ref.19]

E. USER INTERFACES

1. HyperCard or Toolbook

HyperCard or Toolbook can be used to develop a user interface for NPS[4]. The Apple Macintosh personal computer and

the Windows[20] environment, are based on graphical user interface design, using either a mouse or keyboard, and manipulate data in a hypertext mode. HyperCard is a monochrome program that uses shades of black, grey and white to contrast information and Toolbook is a color program. Both have a set of patterns found in its draw and paint palletes and extensive cut and paste libraries. Both can be easily edited from the screen at any time, most of the development process is self-coding and scripting languages are high level, i.e., they have English-like commands.

2. FOCUS

The mainframe or personal computer version of FOCUS can also be used as a user interface development tool for NPS[4]. FOCUS is primarily a database management and report generating program, but has the ability to produce screens for the user to gain access to and manipulate information. FOCUS programs and a terminal keyboard are the present means of user interface for parties involved in the scheduling process.

3. Schedule Cards and Reports

The existing form of user interface is 5" x 8" cards and computer printouts. There are several ways that the reports and programs that produce them can be used by NPS[4]:

[20] Windows is a graphical user interface (GUI) program available from Microsoft, Inc., that can be used on IBM-compatible computers. Many programs can access Windows to provide a GUI environment to their program functionalities.

- Maintain all existing reports, including the schedule cards, and use NPS^4 simply to assist in decision-making. This is the option used in the Prototype Version of NPS^4.

- Since the Schedule Card Program performs the same search, sort and placement routines of SECT file data that are required by NPS^4, this program might be used to generate NPS^4's electronic schedule cards.

- Use NPS^4 as both a DSS for the Class Schedulers and also as a report generator in conjunction with the Schedule Card Program. Instead of printing Student Schedule Cards with partial information as starting data for the Scheduling phase, print out the student cards with their entire schedule as an end-product of the phase, along with schedule cards for instructors and rooms and the Master Instruction Schedule.

- Instead of extracting information from the SECT file and supplementary information to create sets of electronic schedule cards, print out the existing set of Student Schedule Cards and then scan them into NPS^4.

4. Assessment of User Interface Alternatives

The user interface is the most important component of NPS^4. It must have features that not only enable the Class Schedulers to perform their scheduling functions as easily as the present system, but it must encourage the Class Schedulers to use NPS^4 instead of the existing system. With the sole exception of ensuring that NPS^4 functions properly, all other components should be chosen with the user interface in mind.

The user interface must have a method for accessing, retrieving and writing large amounts of data into and out of storage quickly and accurately. In the scheduling process, Class Schedulers frequently locate and retrieve multiple schedule cards with much information on each card, often derived from diverse sources. Course, time and room

information are placed on the cards and the cards returned, the process repeating until the schedule is complete.

Not only must the user interface be able to create the cards on screen rapidly and place information into them, but it must have a way to display multiple cards on the screen. Being able to see information from more than one card at a time is a key element of manual scheduling.

HyperCard and Toolbook meet all these criteria. They both take advantage of graphical user interface design and incorporate a "made-to-order" method of schedule inforamtion retrieval in the form of hypertext. The graphical user interface and mouse access methods are desired features for the Class Schedulers, who have little formal computer experience. They are also capable of displaying multiple cards on a single screen. With the exception of the third iteration of the Department Chairman Report, Class Schedulers have no use for any hard copy reports if they can be replicated on a computer screen. [Ref.37] and [Ref.38]

F. EXPERT SYSTEM ALTERNATIVES

Another approach to the NPS scheduling process is the development of an expert system. An expert system captures human knowledge as a set of facts and procedures in a component called the "knowledge base". From these facts and procedures, the expert system is able to make inferences about conditions with which it is presented through a component

called the "inference engine". The expert system can then give advice or recommendations on actions regarding the present conditions and explain why it made that advice or those recommendations. [Ref.40:p.424-430]

Expert systems (ES) can also be used in conjunction with decision support systems (DSS) in the following ways [Ref.40:p.686-691]:

- An ES can be used as an intelligent interface between the DSS and its database, problem model, or user interface.
- An ES can act as a problem model for a DSS.
- A DSS can act as an input for an ES.
- An ES can be used to help design a DSS like NPS^4.

G. IMPLEMENTATION AND MAINTENANCE

1. Practical Problems and Practical Answers

A key consideration in any information systems (IS) project is implementation and maintenance, requiring money, personnel and commitment to the project. Implementation, like design, also must take into consideration that the NPS scheduling process is an ongoing system. There are few weeks that the Class Schedulers are not busy scheduling. It is an important process, without which NPS can not function effectively, and can not be disrupted by either the development or implementation process.

The NPS^4 presented in this thesis addresses several of these considerations. NPS^4 tries to emulate the present

process rather than redesign it. Therefore, training should be minimal if the Class Schedulers can easily recognize the schedule cards, reports and the process that the program uses. The Prototype Version of NPS^4 is independent of the existing system. There is little or no risk in developing and testing it. The Class Schedulers can test the system and train on it at the same time. They can be entirely confident that the system will work before it is ever seriously used. Because it is independent, the Class Schedulers can fall back on the manual system if needed. When NPSS is incorporated as the problem model, it can be also used independently until the Class Schedulers gain confidence in it.

One important maintenance concern is that NPS^4 would likely be written in either HyperTalk or Openscript. Both are easy to learn, high-level languages, with documentation that show examples of how to write code for many useful functions. With some knowledge of the scripting language, NPS^4 would permit easy editing of any screen as the need for a correction or enhancement is detected. A code change can be made even when the program is stopped and awaiting instructions. Any program code not self-generated by HyperCard or Toolbook is accessible from each screen it affects. Changes can be made and documented in comments within code readily accessible from the displayed screen. Also, NPS^4 operates with HyperCard or Toolbook and does not need to be compiled after each change.

2. System Support

Implementation and maintenance require a supportive environment by the people it affects. Having the support of its intended users is important, but NPS⁴ must also be supported by the people who will install and maintain it over its lifetime (i.e., software life cycle). At NPS, these will most likely be MIS personnel. They must understand the intent of the project, its hardware and software, and the program structure and code. NPS⁴ as we envision it uses a new development program, e.g., HyperCard or Toolbook, which uses a new data handling structure, hypertext, and scripting language, HyperTalk or Openscript. It is also likely to be installed on a personal computer versus a mainframe computer (each of which have their own proponents and philosophies). Prolific documentation of the entire development process is imperative. While a fully documented and workable program will aid in promoting a supportive environment, support will only occur when the project is accepted by all concerned.

H. PROTOTYPING

One development method well suited to decision support systems, and to NPS⁴ in particular, is prototyping. A prototype is a working system that is created to test ideas and the functionalilty of the real system. Steps in devlopment can be tested by the developer and the intended

user for "feel" and accuracy. As development progresses, the prototype begins to look more and more like the final system.

> The underlying principle of prototyping is this: users can point to features they like or dislike and so indicate shortcomings in an existing and working system more easily than they can describe them in a theoretical or proposed system. Experience and use produce more meaningful comment than analysis of charts and narrative proposals.
>
> Systems prototyping is an interactive process. It may begin with only a few functions and be extended to include others that are identified later. It may also start with what both analysis and user believe is a complete set of functions that may expand or contract through use and experience [Ref.42:p.38-39]

Chapter VI gives an example of a prototype that has been developed representing one possible user interface for NPS[4].

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VI. NPS^4 USER INTERFACE PROTOTYPE

A preliminary prototype of a possible user interface for the Prototype Version of NPS^4 has been constructed. It was designed using HyperCard 2.0 on an Apple Macintosh IIci personal computer with 8MB of RAM and a 64K cache card under the System 7 operating system.

A. PROTOTYPE DESIGN

1. Operational Functionalities

The NPS^4 prototype system was designed to incorporate the following operational functionalities:

- An interactive user interface which meets the functional requirements of its users (e.g., Class Schedulers).
- A standard Macintosh window environment with mouse-based graphical interfaces.
- A context-sensitive help system to enable the user to make inquiries to the program regarding the functionality of specific features of each screen.
- A security system to ensure a potential user is authorized to use NPS^4 and gain access to the information contained in it and information NPS^4 can access from the mainframe.
- Ability to load scheduling data from FOCUS language files on the NPS mainframe.
- Ability to create a new schedule file and assign to it a version name.
- Automatic saving of changes as they are made to the schedule file so the user will not have to remember to save work.
- Ability to save schedule files on the personal computer.

- Ability to load a copy of an existing file by selection of its version name in an interactive dialog box.

- Ability to create as many files as desired during each session with the program.

- Ability to delete any indicated schedule files.

- Prompt the user for a new version name before closing a schedule file and provide a name automatically if no name is given.

- Ability to make an entry into the time period text fields of a schedule card only if the entry does not create a conflict with another entry, i.e., the system will check for entries in that same time period.

- Display conflicts resulting from attempted schedule card entries and provide alternative selections.

- Provide a list of courses remaining to be scheduled that will be updated automatically after every successful entry in made to a schedule card.

2. Design Constraints

In addition to the capabilities listed above, the prototype was designed with the following constraints:

- Correctness. The program must be correct in the manner in which it performs scheduling functions. The program must be approved by the intended user, i.e., the Class Scheduler. Rapid prototyping is used to obtain and verify user requirements.

- Data Security/Reversal of Actions. The DSS should operate with a copy of the mainframe scheduling information. Each application of an NPS^4 function that would create a new version must automatically archive the old version, enabling the user to retrieve old data.

- Response Time/Efficiency. In the early stages of NPS^4 development, HyperCard provides nearly instantaneous display of a full page of graphics and text. Screens do not change without action from the Class Schedulers, so they can read text at their own pace.

- Expandability. Scripted hypertext in the HyperTalk language provides developers the capability to easily expand the user interface to include enhancements.

- Maintainability. HyperCard is an off-the-shelf application development package with good documentation and reference support that provides automatic code-generation and high-level language scripting.

- Excessive Functionality. Developers and users will continually prioritize NPS[4] functions to develop those absolutely needed for scheduling and defer development of others for later versions of the project.

- Documentation. Documentation will be profuse. All modules will contain comments on their functionality, rationale for their development and the purpose of all features. Variables names will be logical to persons not associated with NPS scheduling.

- Training. Rapid prototyping with user involvement in the development process will lessen the need for training. The prototype will approximate the appearance and performance of the final product as closely as possible.

3. User Inputs

The following are intended user inputs to the program:

- PASSWORD - a sequence of up to 60 keyboard characters, terminated by the Enter key. The sequence may include any keyboard characters, e.g., spaces and non-alphanumeric characters.

- FILENAME - a sequence of eight alphanumeric and non-embedded underscores, starting with a letter. This corresponds to allowable filenames in NPS mainframe files. The first three characters will be a standard month abbreviation (e.g., JAN), the next two characters a day of the month (e.g., 09), the next character an underscore (_) and the last two characters a sequence number (e.g., 02) to be used in case more than one schedule file is created on the same date.

- FILETYPE - "schedule". This corresponds to allowable filetypes in NPS mainframe files, i.e., a sequence of eight alphanumeric and non-embedded underscores. This will allow easy identification of schedule files.

- FILEMODE - "a0". This corresponds to allowable NPS mainframe filemodes, i.e. a two character sequence of a letter and a number that indicates a user's secondary storage disk on the mainframe. This will provide read and write protection from all other users on the mainframe.

- ROOM FIELD - a valid NPS course and segment number, followed by the number of students in the segment, followed by the last name of the segment's instructor.

- INSTRUCTOR FIELD - a valid NPS course and segment number, followed by the classroom number, followed by the number of students in the segment.

- STUDENT FIELD - a valid NPS course and segment number, followed by the classroom number, followed by the last name of the segment instructor.

4. Program Outputs

The following are program outputs to the user:

- LOADING FILE - the filename, filetype and filemode of the schedule the user has requested to load for editing.

- DELETING FILE - the filename, filetype and filemode of the schedule the user has requested to delete.

- ROOM CARDS - a series of cards with the five days of the academic week down the left side and time periods of an academic day across the top, "Classroom" identification at the bottom left corner and the complete ROOM FIELD information for each segment taught in that classroom.

- INSTRUCTOR CARDS - a series of cards with the five days of the academic week down the left side and time periods of an academic day across the top, "Instructor" identification at the bottom left corner and the complete ROOM FIELD information for each segment taught by that instructor.

- STUDENT CARDS - a series of cards with the five days of the academic week down the left side and time periods of an academic day across the top, "Student" identification at the bottom left corner and the complete ROOM FIELD information for each segment taken by that student.

5. **Program Functions**

The following functions are presently supported by the NPS[4] user interface prototype:

- ACADEMIC QUARTER & YEAR ENTRY - the system generates default entries based upon the current date and time. However, the user can change the quarter and year if desired.

- COURSE & SEGMENT NUMBER ENTRY - a course and segment number may be entered on the first line of any valid box in the day/time period matrix for a student, instructor or room schedule card.

- FILE REVIEW - the user may review a previously saved schedule iteration file.

- FILE DELETION - the system automatically deletes the oldest schedule iteration file when the user saves another file and three previous iterations already exist.

- FILE CREATION - when requested by the user, the system creates a new schedule iteration file. The filenames are internally generated and include the date the file was created or subsequently edited. The rest of the filename consists of a sequence number, designed to handle the situation where more than one file is created/edited during the same day.

- HELP - a context-sensitive help system is available at the push of a button from anywhere within the NPS[4] system. Upon closing of the help window, the user is returned from where they came.

- INSTRUCTOR CARD CREATION - an Instructor Schedule Card, corresponding to a specified office code, can be created. The office code is verified.

- INSTRUCTOR CARD DELETION - an Instructor Schedule Card, corresponding to a specified office code, can be deleted. The office code is verified.

- INSTRUCTOR OFFICE CODE ENTRY - a five character office code may be entered upon creation of an Instructor Schedule Card. The office code is verified that it is a valid two letter academic department code, followed by a "/", followed by a valid two letter professor name abbreviation.

- PASSWORD ENTRY - a blinking cursor is autopositioned in the password entry box in the welcome screen. Up to a 60 character password will be visible.

- QUIT - this allows the user to quit the NPS[4] program at any time.

- ROOM CARD CREATION - a Classroom or Laboratory Schedule Card can be created. The classroom number is verified.

- ROOM CARD DELETION - a Classroom or Laboratory Schedule Card can be deleted. The classroom number is verified.

- ROOM NUMBER ENTRY - a valid room number may be entered on classroom, professor, or student card. The room number is verified to be in a five character form of a valid one character academic building abbreviation, followed by a "-", followed by a valid three digit classroom number within that building.

- SEATING & CLEARANCE ENTRY - the user may enter the seating capacity, seating type, and room clearance on a room schedule card.

- STUDENT CARD CREATION - a Student Schedule Card, corresponding to a specific Student Course Group, can be created. The student card number is verified.

- STUDENT CARD DELETION - a student card, corresponding to a specified student group number, can be deleted. The student group number is verified.

- STUDENT COURSE GROUP NUMBER ENTRY - a six character Student Course Group number may be entered upon creation of a Student Schedule Card. The Student Course Group number is verified that it is a valid curriculum section number (e.g., PM21), followed by a valid sequence number within that curriculum section. A single digit sequence number is preceded by a blank.

- TASK SELECTION - the user may select whether to create a new schedule iteration file or review an old one.

B. PROTOTYPE SCREENS

Figures 6.1-6.16 show the prototype user interface screens. The following is a brief description of each screen and their features:

1. Introductory Screens

Figure 6.1 WELCOME. Provides a warning as required for a government system. Prompts the user for a password. If the user is unfamiliar with the system, there is a contextual Help feature. Quitting the program is also an option.

Figure 6.2 MAIN MENU. Presents options to create a new schedule iteration or review an old schedule iteration. Help and Quit are also available.

Figure 6.3 REVIEW FILE. Prompts the user to select a schedule iteration for further work. Only the last three iterations are saved. The filenames are internally generated and include the date the file was created or subsequently edited. The rest of the filename consists of a sequence number, designed to handle the situation where more than one file is created/edited on a day. Help and Quit are also available.

Figure 6.4 LOAD WAIT. Provides feedback to the user while the system searches for the requested schedule iteration file. The filename/filetype/filemode is redisplayed so the user may confirm the system is searching for the correct file.

Figure 6.5 SELECT CARD TO EDIT. Upon successful location of the requested schedule iteration file, the user is requested to select either a classroom, professor, or student card for editing. Return sends the user back to the main menu, to allow creation of a new schedule iteration without exiting the program. Help and Quit are also available.

Figure 6.6 AUTO FILE DELETION & CREATION. Upon creation of a new schedule iteration file, the system checks to see if three previous iterations exist, and if so, automatically deletes the oldest one. The user is then informed of the name given to the new schedule iteration file. Return sends the user back to the main menu. Help and Quit are also available.

Figure 6.7 AUTO FILE CREATION ONLY. If three previous iterations do not exist, the user need only be informed of the name given to the new schedule iteration file. Return sends the user back to the main menu. Help and Quit are available.

Figure 6.8 SELECT CARD TO CREATE. The user is requested to select either a classroom, professor, or student card for creation. Return sends the user back to the main menu, to allow creation of a new schedule iteration without exiting the program. Help and Quit are also available.

Figure 6.9 HELP SCREEN. Scrolling field displayed whenever the Help button is pushed within NPS[4]. The "OK, Go Back" button returns the user to where they were previous to pushing the Help button.

2. Classroom or Laboratory Schedule Cards

Figure 6.10 ROOM CARD TEMPLATE. Internally used within the HyperCard system for creation of new Classroom or Laboratory Schedule Cards as needed. The Classroom number and the Seating and Clearance information are input by the scheduler when a new card is desired. A default value for the Academic Quarter and Year are internally generated, based upon the current date. The serial number is internally generated to aid in distinguishing among cards.

Figure 6.11 ROOM CARD SAMPLE. Within the day/time period matrix is shown the course segments which have so far been scheduled for this classroom. The course segment information consists of the course and segment number, the number of students so far scheduled for this segment, and the instructor's name.

3. Instructor Schedule Cards

Figure 6.12 INSTRUCTOR CARD TEMPLATE. Internally used within the HyperCard system for creation of new Instructor Schedule Cards as needed. The Office Code and the Courses to be taught are input by the scheduler when a new card is desired. A default value for the Academic Quarter and Year are internally generated, based upon the current date. The serial number is internally generated to aid in distinguishing among cards. The instructor's name is internally generated based upon the Office Code.

Figure 6.13 INSTRUCTOR CARD SAMPLE. Within the day/time period matrix is shown the course segments which have so far been scheduled for this instructor. The course segment information consists of the course and segment number, the classroom number, and the number of students so far scheduled.

4. Student Schedule Cards

Figure 6.14 STUDENT CARD TEMPLATE. Internally used within the HyperCard system for creation of new Student Schedule Cards as needed. The Student Course Group number and the courses to be taken are input by the scheduler when a new card is desired. Any courses which don't fit in the Tuesday 1610-1700 box in the day/time period matrix are overloads and go in the Overloads field. The number and list of student name(s) in the group is internally generated based upon the Student Group number. The serial number is internally generated to aid in distinguishing among cards.

Figures 6.15-6.16 STUDENT CARD SAMPLE. Within the day/time period matrix is shown the course segments which have so far been scheduled for this student. The course segment information consists of the course and segment number, the classroom number, and the last name of the instructor.

C. USER CRITIQUE

The Class Schedulers, the Management Analyst, and persons not familiar with the NPS scheduling system, were shown the prototype screens. Initial feedback that helped shape the

appearance and functions of the final set of screens is presented below (Class Schedulers' comments have an asterisk beside them):

- WELCOME (Figure 6.1)
  --- Show a cursor in the password entry box
  --- Provide instructions for password entry
  --- How long can the password be?
  --- What format can the password be?
  --- Make the welcome larger and the warning smaller
  --- Use a visual effect in the welcome
  --- Show a face in the greeting

- MAIN MENU (Figure 6.2)
  --- Use more businesslike terminology, e.g. "please choose one of the following", versus "tell me"
  --- Can you review or scan schedules?
  --- Don't use an abbreviation for the name of the system
  --- Where does Return take you? Would Quit take you the same place?
  --- What do you do with the buttons and the mouse?
  --- *Save three iterations, i.e., schedule files, vice explicit user deletion
  --- *Provide expert user with direct access to functions via keyboard equivalents

- REVIEW FILE (Figure 6.3)
  --- Explain filename, filetype and filemode; why are they one word?
  --- Provide a directory, e.g., pop-up scrolling field, from which to choose an existing file
  --- Explain that the Enter key must be hit after entry of the filename
  --- What are the functions of Quit and Return?
  --- What is the file?
  --- How is the filename determined?
  --- Will Quit save the file prior to logoff?
  --- Will the file be saved with a new filename if no changes were made?

- LOAD WAIT (Figure 6.4)
  -- Provide a clock to countdown or some other feedback of how long it will take to load a file
  --- Provide an interrupt button if you change your mind about loading this file
  --- Provide wait messages during loading, even if it is virtually instantaneous
  --- Provide selection via a pop-up scroll field

--- Provide last file updated as the default file to load
--- *Can two persons have access to the same file?

- FILE NOT FOUND! (deleted card)
  --- Explain that typeover of the old filename is desired
  --- Allow the user to select a filename versus automatic computer selection of the filename
  --- Selection via a pop-up scrolling field would make this screen obsolete
  --- *I like the computer-selected filename idea

- SELECT CARD TO EDIT (Figure 6.5)
  --- For exper users, provide command-driven navigation versus a button hierarchy
  --- Provide a list of commands at the bottom of the screen
  --- Highlight the default command
  --- Enable arrow keys for navigation
  --- Allow the user to go directly to a specific card of each type
  --- *What cards do you look at first?
  --- *Allow scheduling by classroom, as well as student group
  --- *Show instructor constraints and available classrooms on cards

- AUTO FILE DELETION AND CREATION (Figure 6.6)
  --- Provide a directory, e.g., pop-up scrolling field from which to choose an existing file
  --- Provide directions on how to choose a file
  --- *Get rid of this card; auto-delete files older than the last two and the current file - keep the most recent three files

- DELETE VERIFICATION (deleted card)
  --- *Get rid of this card; auto-delete files older than the last two and the current file - keep the most recent three files

- DELETION ACCOMPLISHED; WHAT NEXT? (deleted card)
  --- *Get rid of this card; auto-delete files older than the last two and the current file - keep the most recent three files

- AUTO FILE CREATION ONLY (Figure 6.7)
  --- new card; no feedback yet....

- SELECT CARD TO CREATE (Figure 6.8)
  --- Everyone liked this screen!

- HELP SCREEN (Figure 6.9)
  --- new card; no feedback yet....

- ROOM CARD TEMPLATE (Figure 6.10)
  --- Provide a capability to scroll through these cards
  --- Provide a capability to go to a specific card
  --- Move the buttons and schedule_type to the top of the card
  --- Move as many actions as possible into menus on the card as opposed to previous screens
  --- I like the readability of the schedule
  --- *For each entry, tell how many class hours conflict with which course segments
  --- *Make the times 0810-0900, etc.
  --- *Show seating information at the bottom, i.e., seating capacity and type of tables/desks, whether classified courses can be taught there, etc.
  --- *Show the room number at the bottom
  --- *Show the academic quarter and year at the bottom
  --- *Show the number of students assigned SO FAR to each course segment
  --- *Show the initials, last name and code of the instructor

- INSTRUCTOR CARD TEMPLATE (Figure 6.12)
  --- Provide a capability to scroll through these cards
  --- Show each instructor's course offerings
  --- Show each instructor's preferences
  --- Explain the different cursors and give instructors on what to do on this screen
  --- I like the hours versus periods across the top
  --- I like the readability of the schedule
  --- *Make the times 0810-0900, etc.
  --- *Show the academic quarter and year at the bottom
  --- *Show the number of students assigned SO FAR to each course segment
  --- *Show the initials, last name and code of the instructor

- STUDENT CARD TEMPLATE (Figure 6.14)
  --- Provide a capability to scroll through these cards
  --- Show the names of the students in each group
  --- Show all courses the students are taking
  --- Move the buttons and schedule type to the top of the card
  --- Move as many actions as possible into menus on the card as opposed to previous screens
  --- I like the readability of the schedule
  --- Check that all the courses are scheduled
  --- Put the names of the students in the course group in a separate file (avoid bells and whistles)
  --- *Show the section/group number on each card
  --- *Show the initials, last name and code of the instructor

--- *For each entry, tell how many class hours conflict with which course segments

--- *Make the times 0810-0900, etc.

--- *Show the number of students assigned SO FAR to each course segment

--- *Show the academic quarter and year at the bottom

--- *Show the names of at least five students in each group

- Other general comments:

--- A touch screen for card creation/editing would be an optimal user interface

--- Place a unique border around the different types of cards

--- I like the autosave feature that avoids loss of even one session

--- *Small class sizes, finals and special equipment needs require scheduling by classroom

--- *Key to system usefulness is input of constraints and allowing the user to change them

--- *Include final exam cards (larger classrooms needed to separate students)

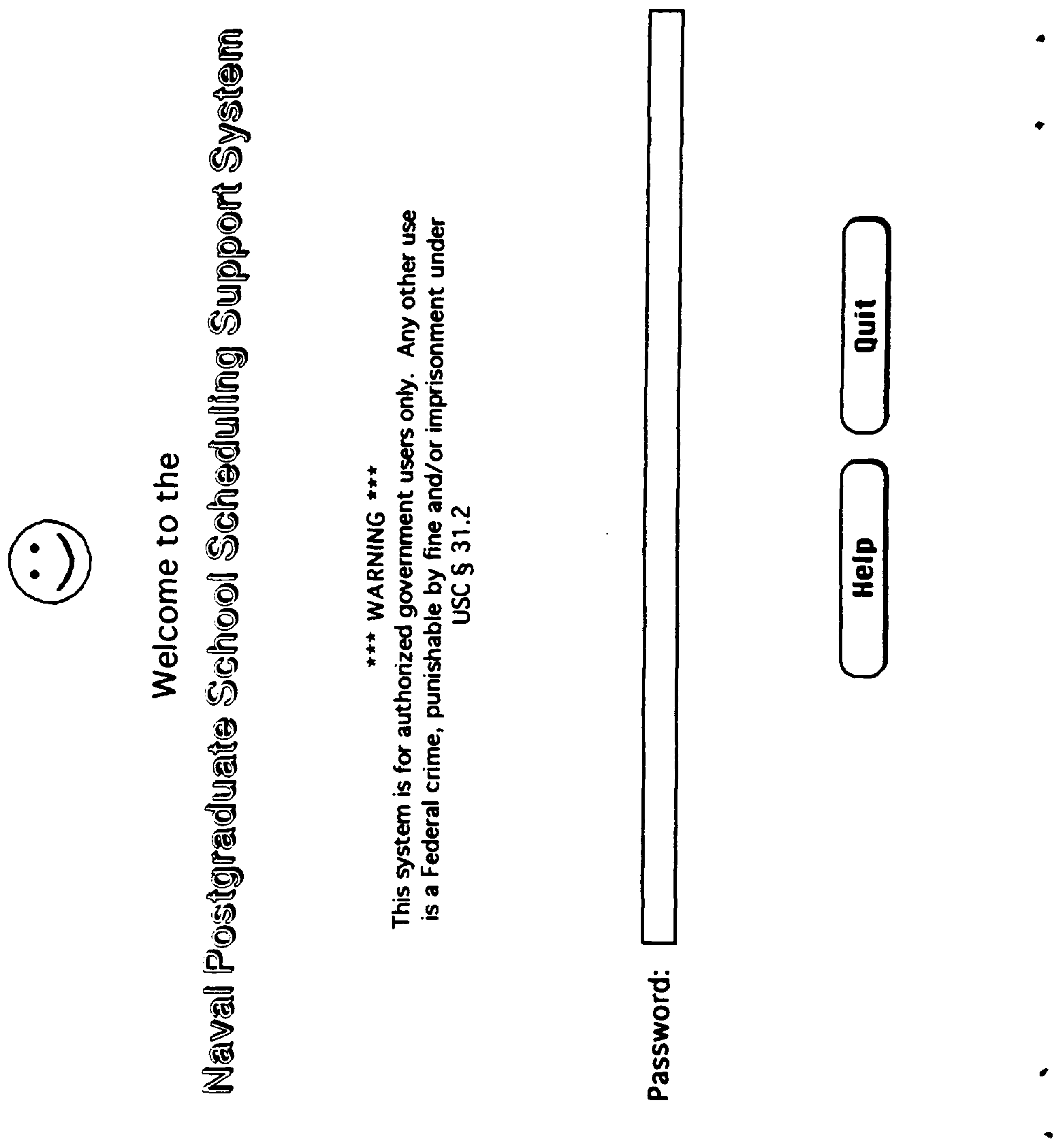

Figure 6.1 Welcome

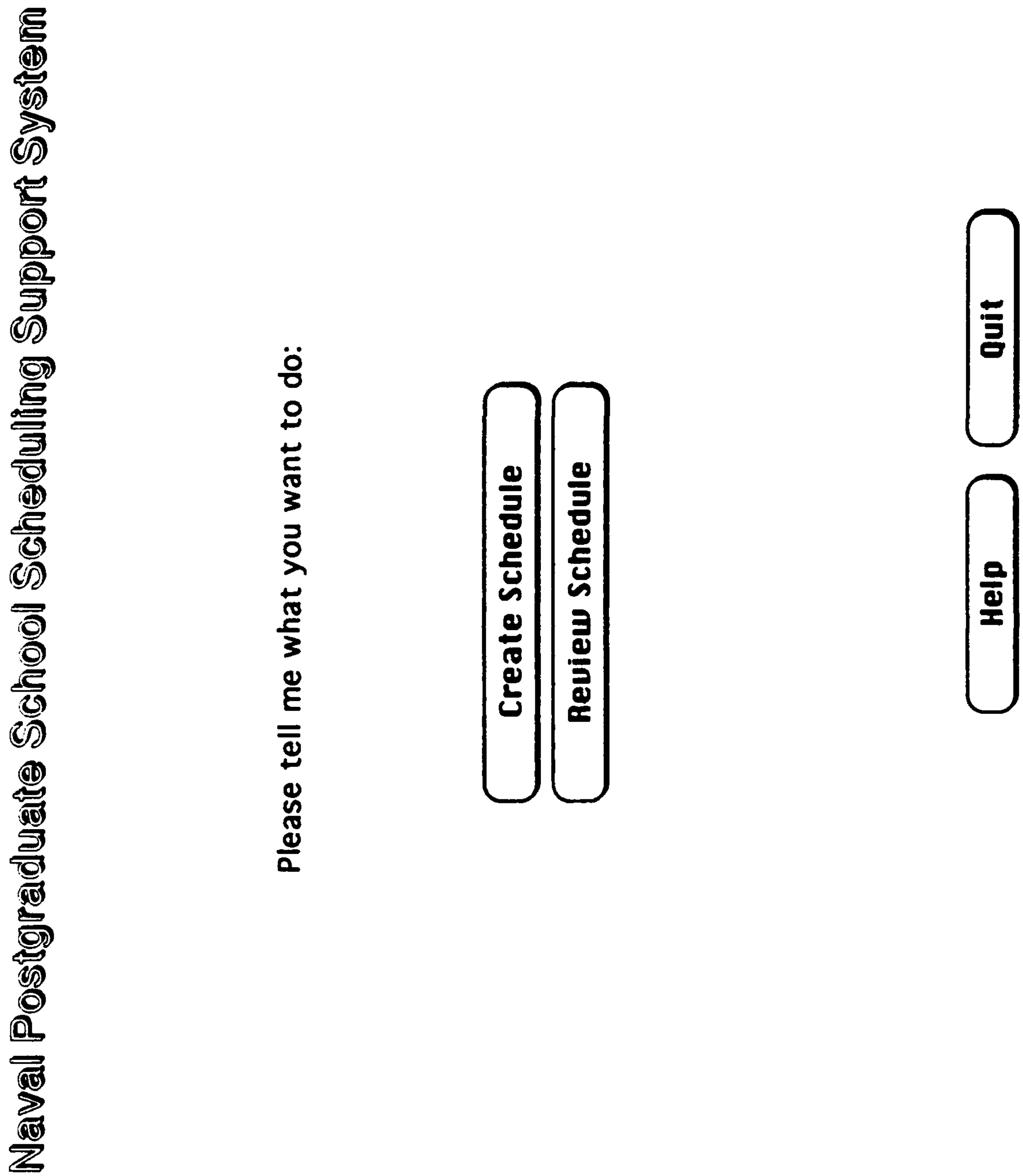

Figure 6.2 Main Menu

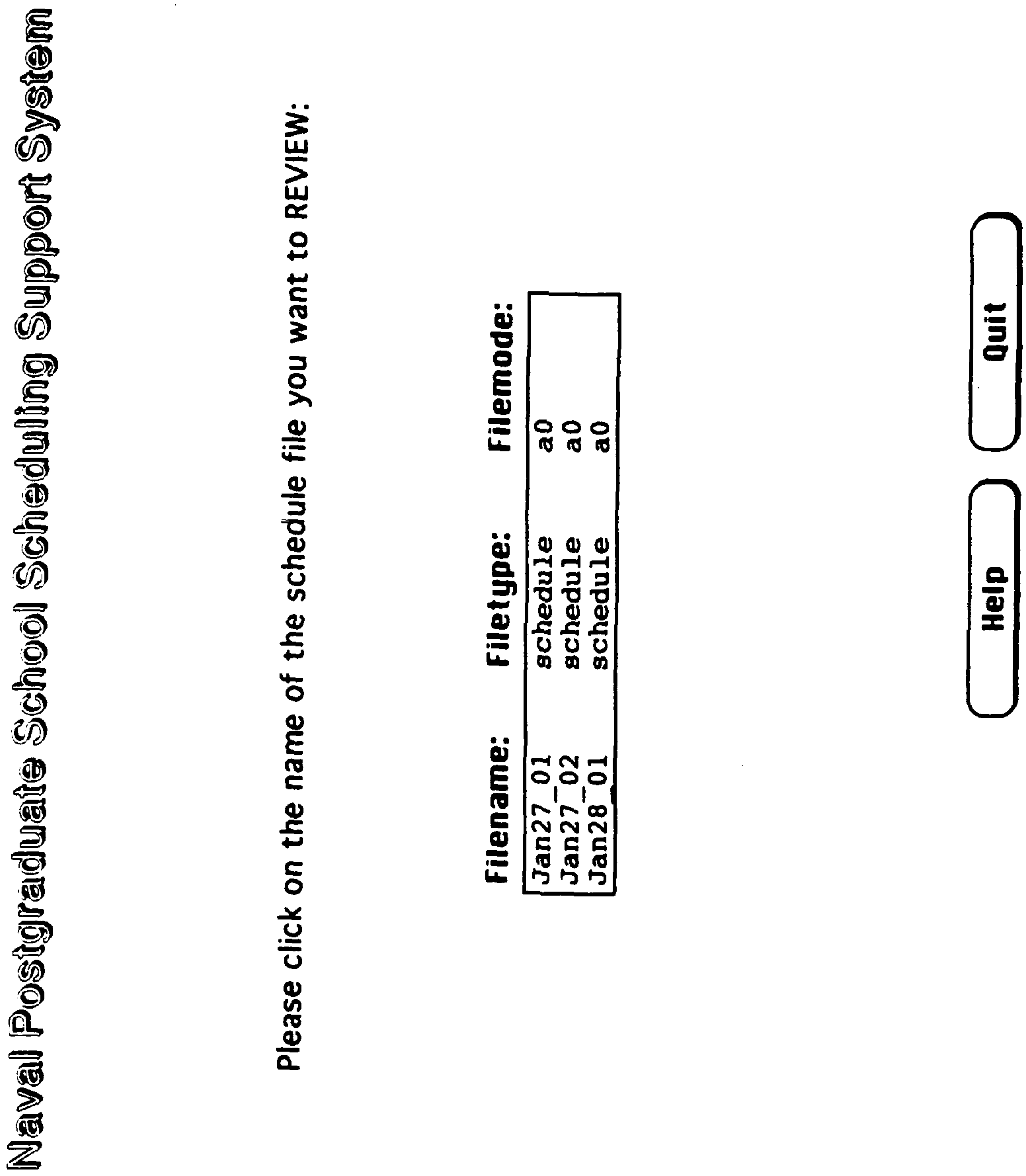

Figure 6.3 Review File

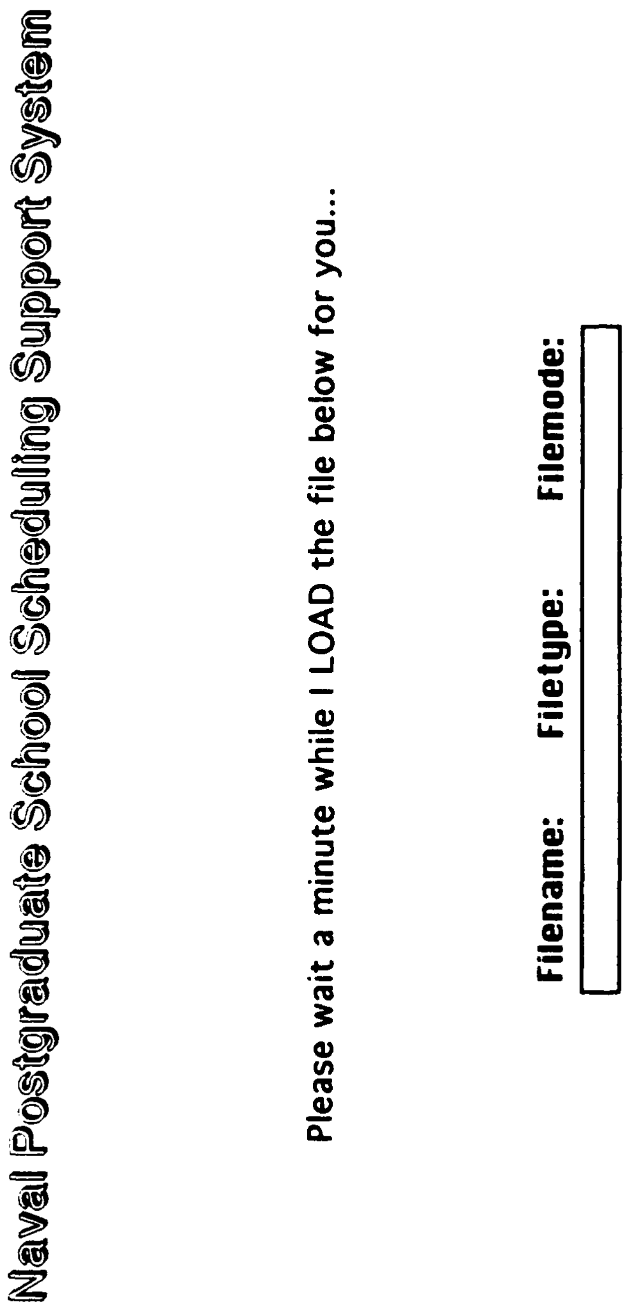

Figure 6.4 Load Wait

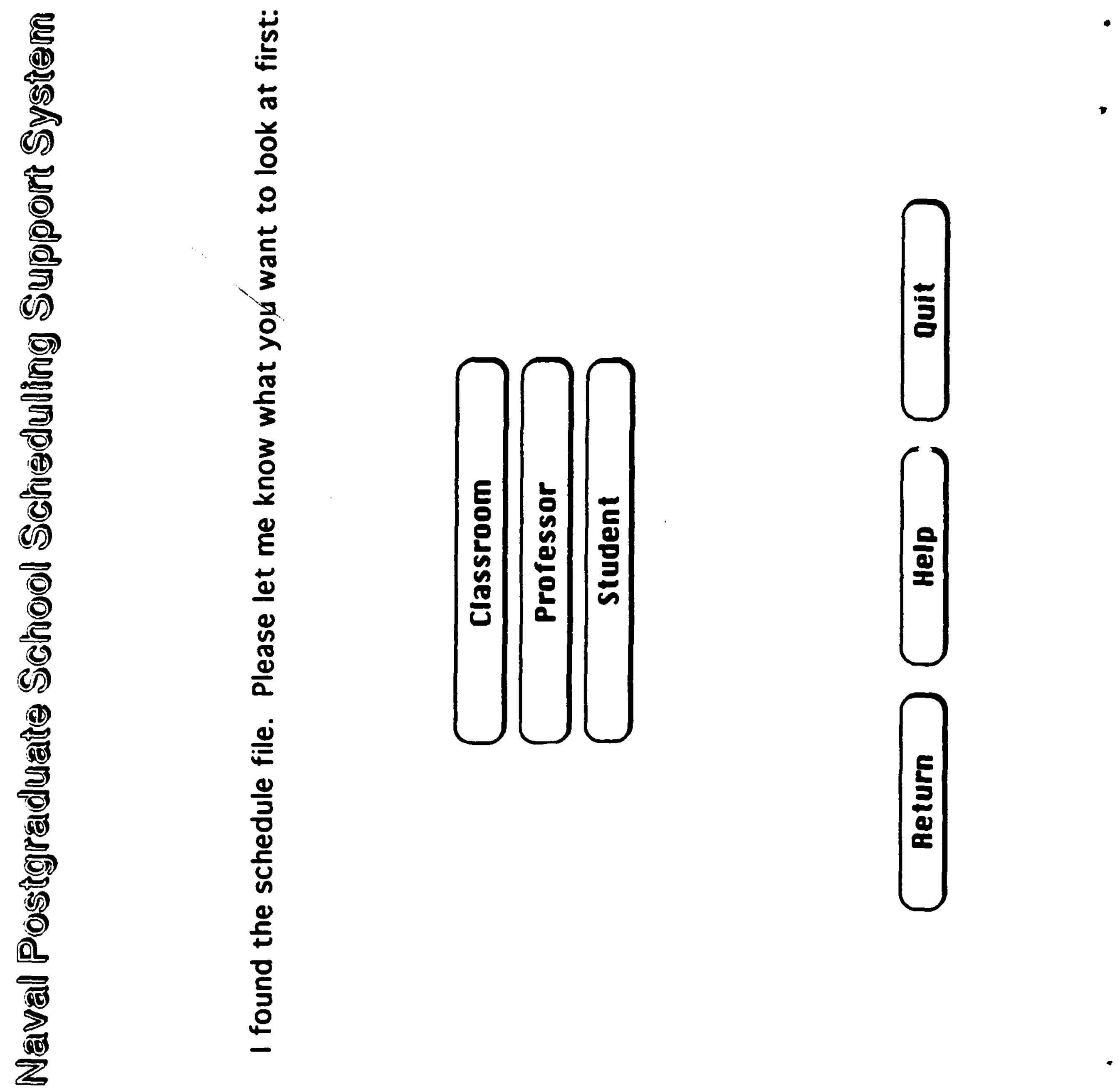

Figure 6.5 Select Card to Edit

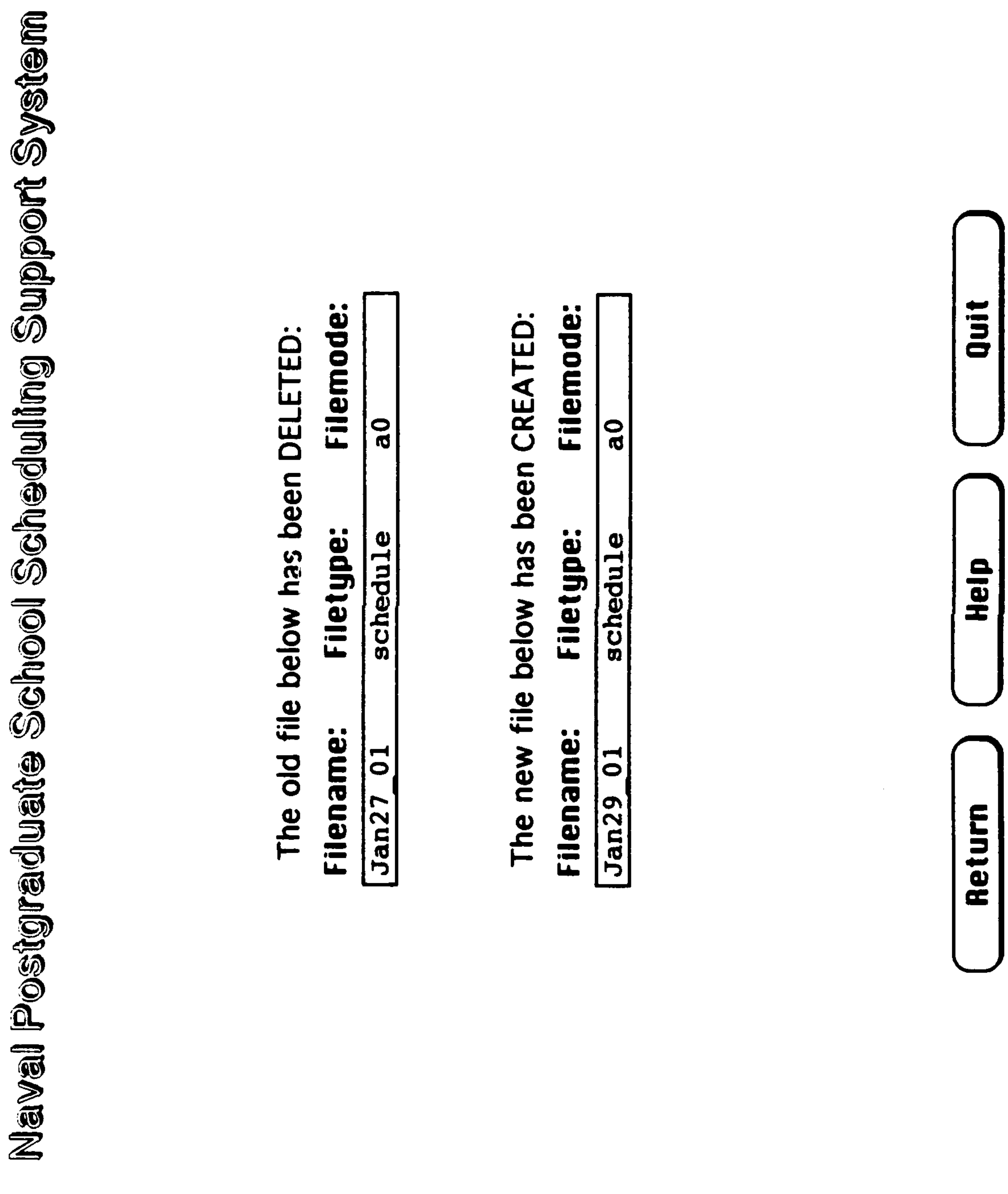

Figure 6.6 Auto File Deletion and Creation

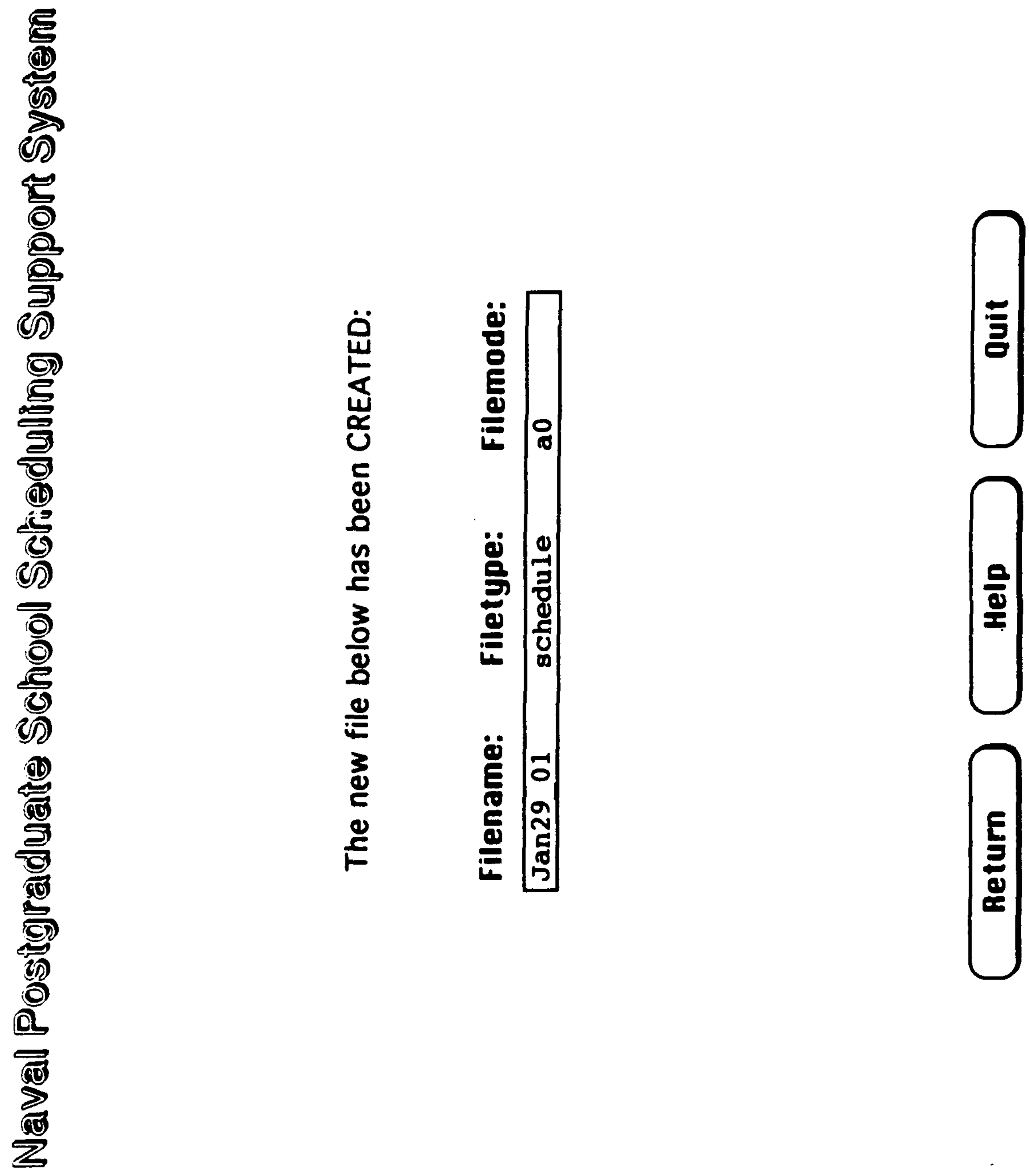

Figure 6.7 Auto File Creation Only

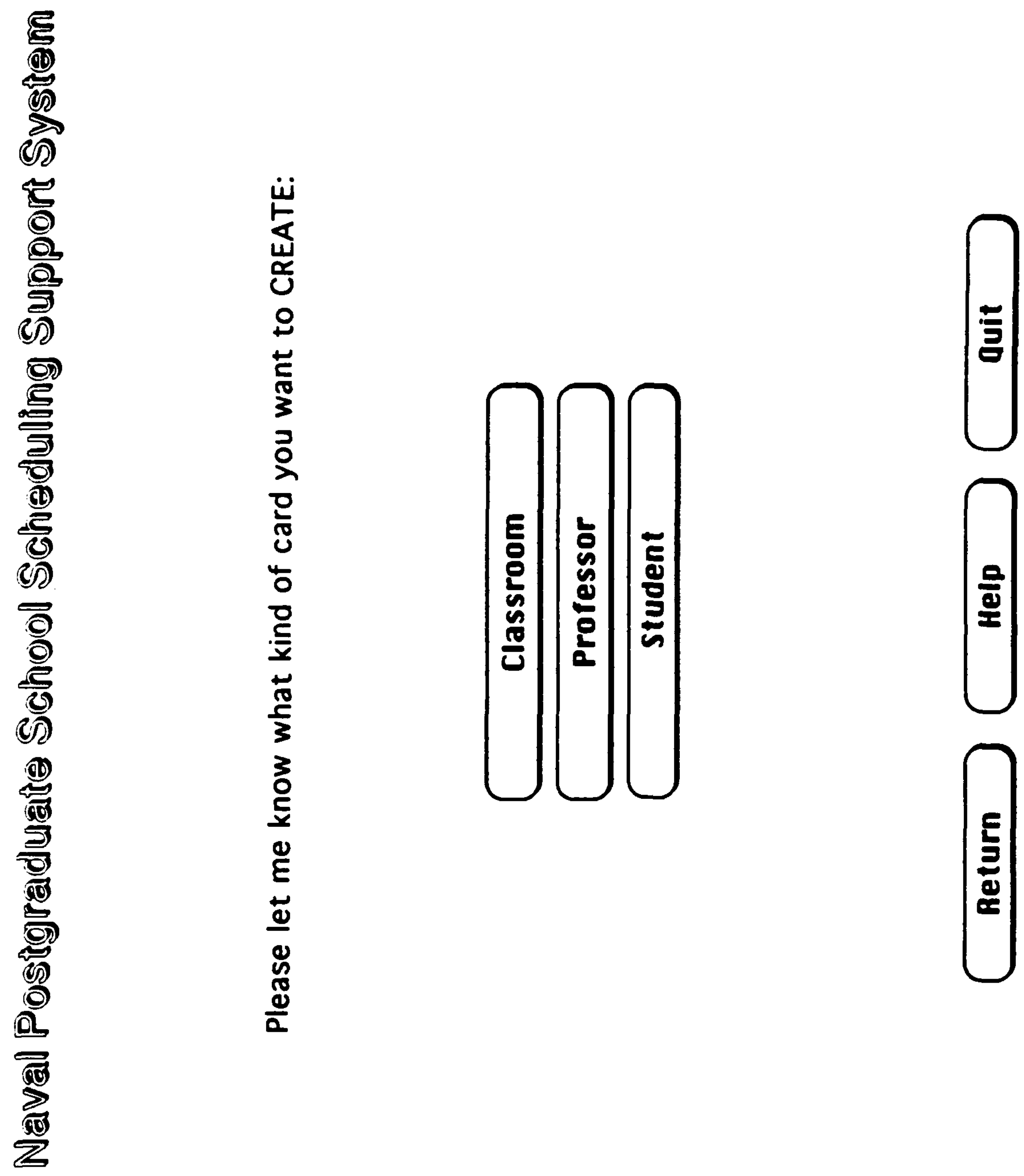

Figure 6.8 Select Card to Create

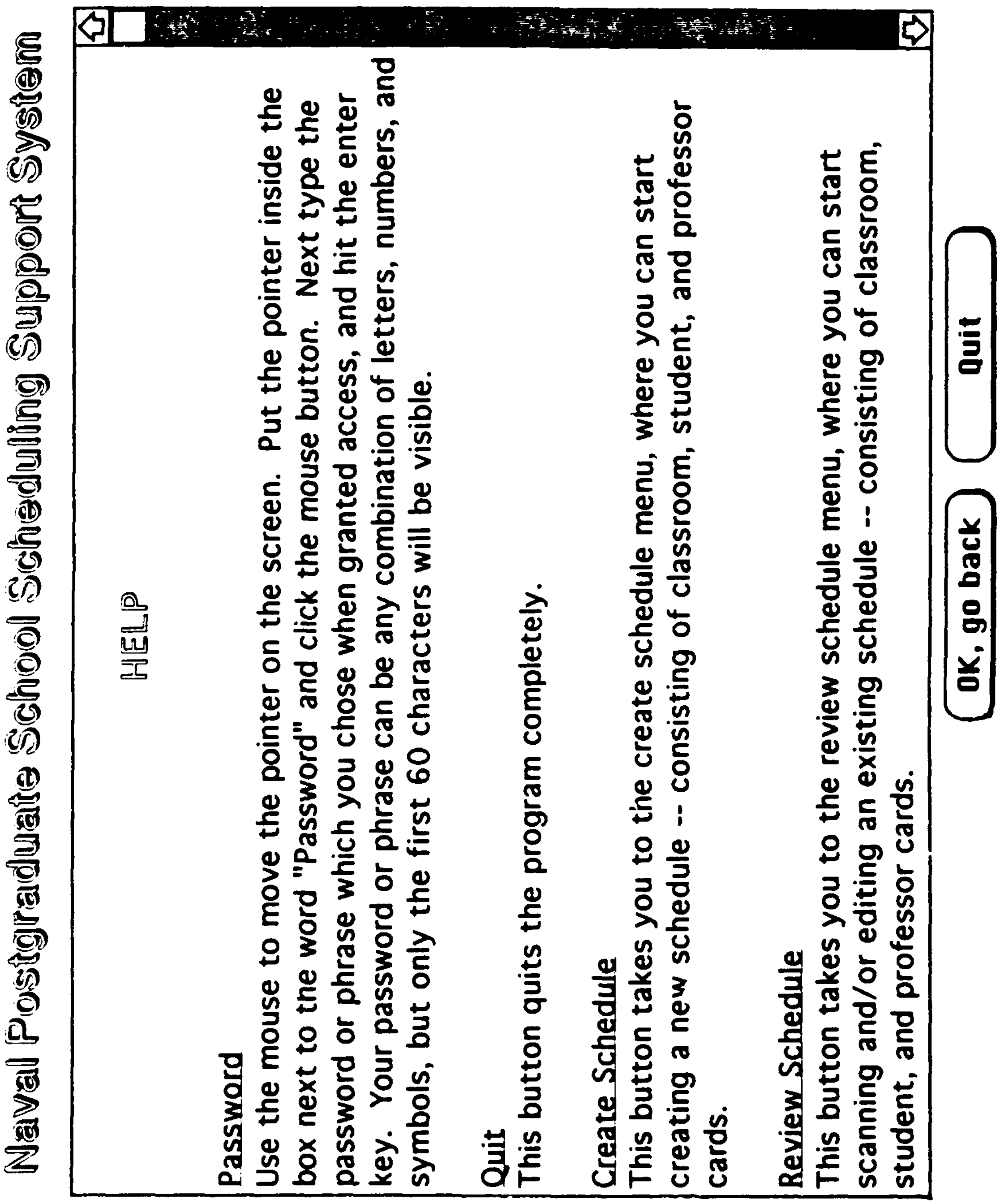

Figure 6.9 Help

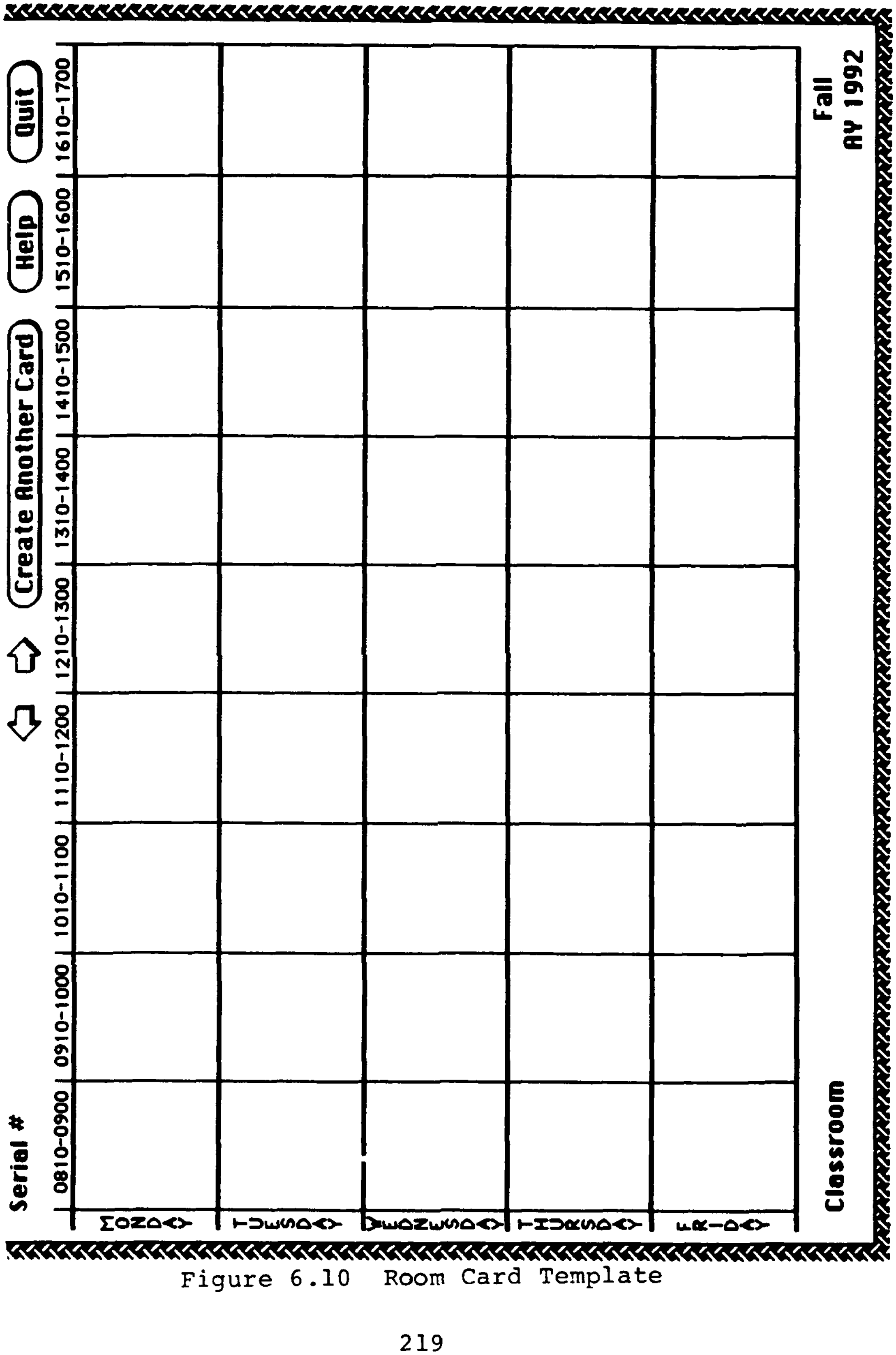

Figure 6.10 Room Card Template

Serial # 169

Create Another Card | Help | Quit

	0810-0900	0910-1000	1010-1100	1110-1200	1210-1300	1310-1400	1410-1500	1510-1600	1610-1700
MONDAY	CS4203 21 students Erickson	EO3750-2 23 students Schwendtne	EC2500 22 students Fargues	EC2420 16 students Tummala	EC3550 16 students Pieper	CS3010-3 24 students Zaky	CS3030-2 24 students Hsiao		
TUESDAY	CS4203 21 students Erickson	EO3750-2 23 students Schwendtne			EC3550 16 students Pieper	CS3010-3 24 students Zaky	CS3030-2 24 students Hsiao		
WEDNESDAY	CS4203 21 students Erickson	EO3750-2 23 students Schwendtne	EC2500 22 students Fargues	EC2500 22 students Fargues		CS3010-3 24 students Zaky	CS3030-2 24 students Hsiao		
THURSDAY	CS4203 21 students Erickson	EO3750-2 23 students Schwendtne		EC2420 16 students Tummala	EC3550 16 students Pieper	CS3010-3 24 students Zaky	CS3030-2 24 students Hsiao	EC2610 15 students Wadsworth	EC2610 15 students Wadsworth
FRIDAY	CS4203 21 students Erickson	CS4311 7 students Kwak		EC2420 16 students Tummala					

Classroom S-408 36 T Fall AY 1992

Figure 6.11 Room Card Sample.

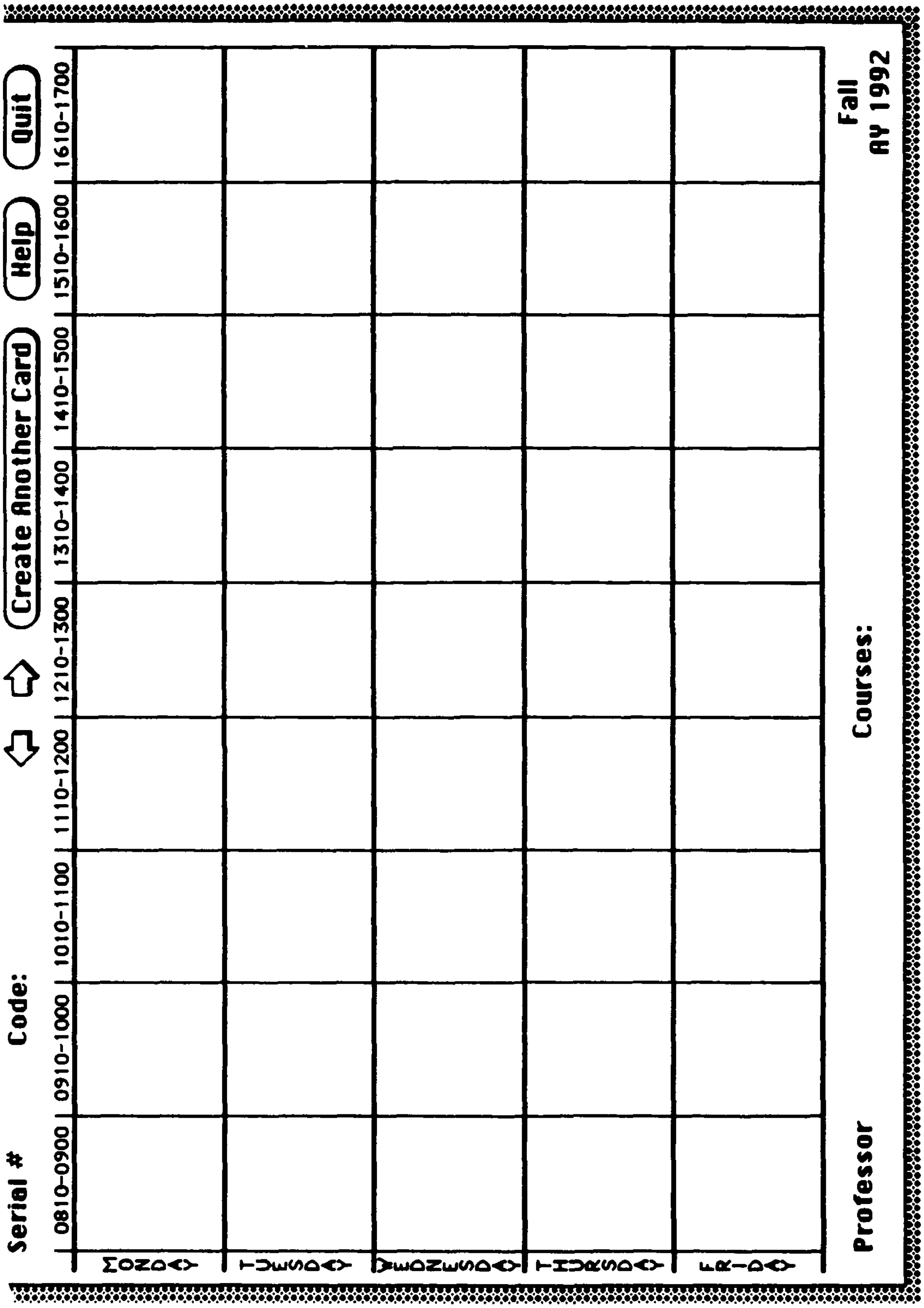

Figure 6.12 Instructor Card Template

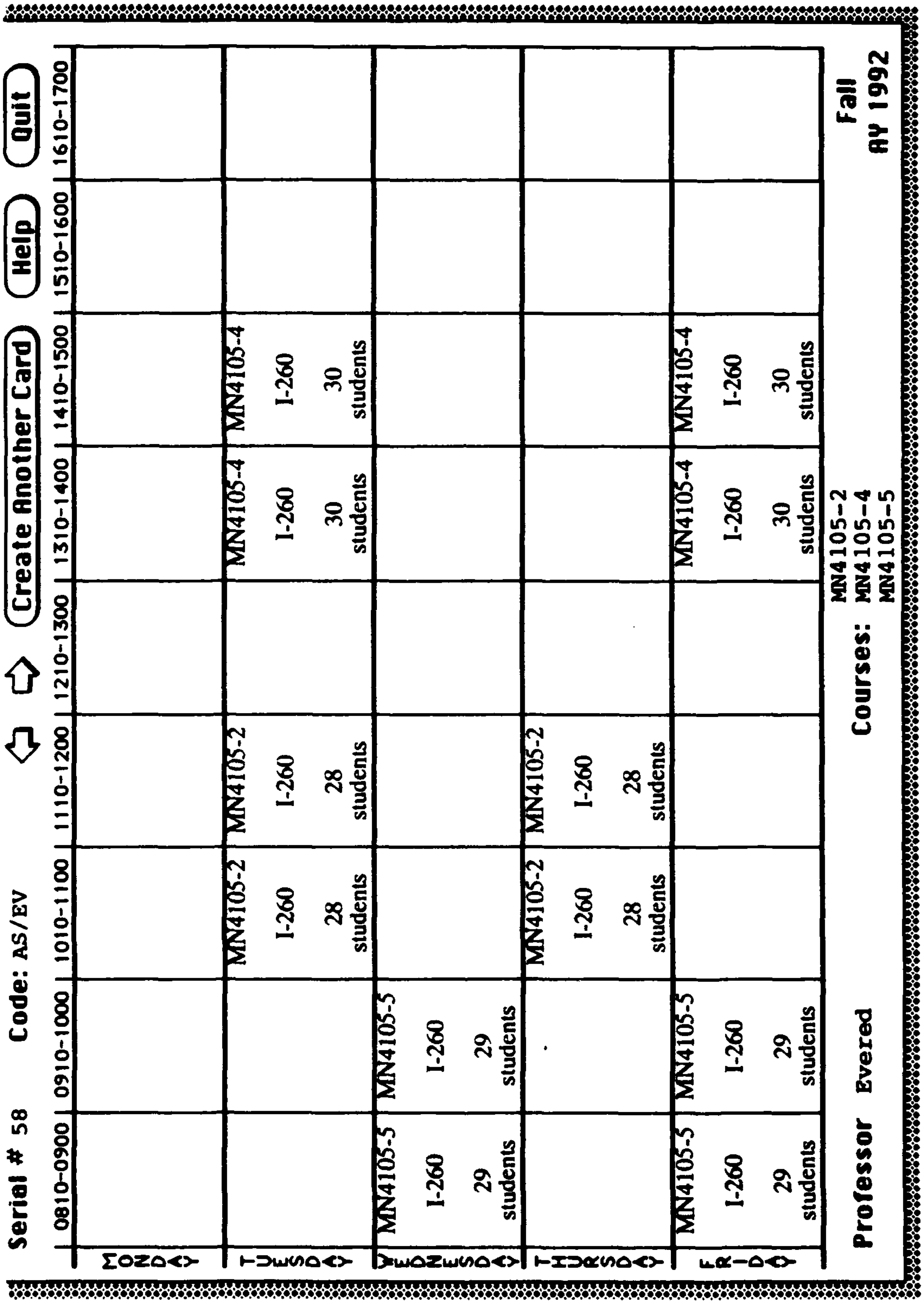

Figure 6.13 Instructor Card Sample

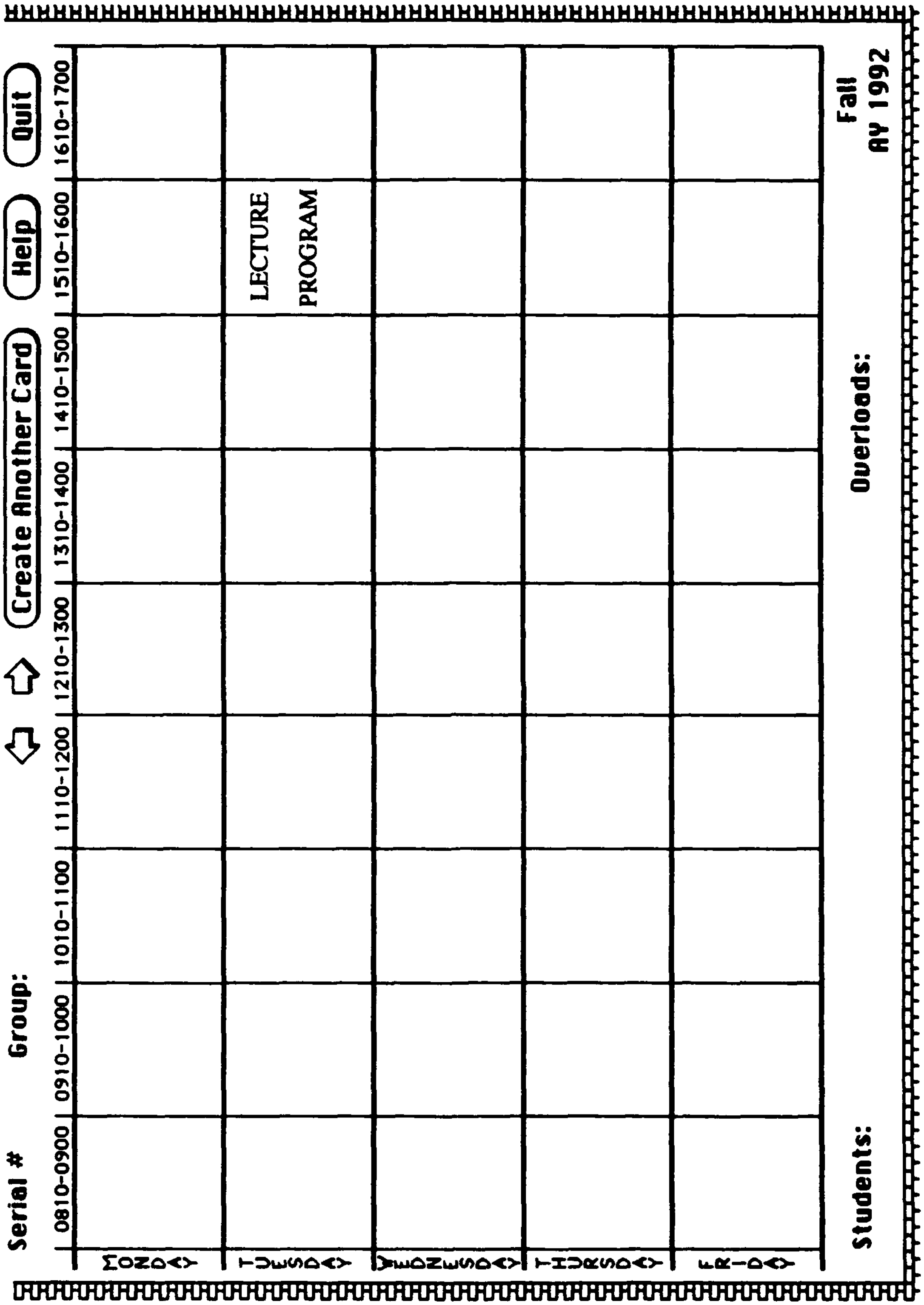

Figure 6.14 Student Card Template

Serial # 169 Group: PL11 8 Create Another Card Help Quit

	0810-0900	0910-1000	1010-1100	1110-1200	1210-1300	1310-1400	1410-1500	1510-1600	1610-1700
MONDAY	CS4203 S-408 Erickson		MN3154-2 I-271 Eberling			IS4300-2 I-265 Zweig	IS4300-2 I-265 Zweig		
TUESDAY	CS4203 S-408 Erickson		MN3154-2 I-271 Eberling					LECTURE PROGRAM	CS4203 IS0001 IS0810 IS4300 MN3154
WEDNESDAY	CS4203 S-408 Erickson		MN3154-2 I-271 Eberling			IS4300-2 I-265 Zweig	IS4300-2 I-265 Zweig		
THURSDAY	CS4203 S-408 Erickson		MN3154-2 I-271 Eberling					IS0001 S-321 Bui	IS0001 S-321 Bui
FRIDAY	CS4203 S-408 Erickson								

Students: (2) Rust Youngblood Overloads: Fall AY 1992

Figure 6.15 Student Card Sample #1

Serial # 170 Group: PL11 9 Create Another Card Help Quit

	0810-0900	0910-1000	1010-1100	1110-1200	1210-1300	1310-1400	1410-1500	1510-1600	1610-1700
MONDAY	CS4203 S-408 Erickson			OS3404-1 I-119 Poock		IS4300-2 I-265 Zweig	IS4300-2 I-265 Zweig		
TUESDAY	CS4203 S-408 Erickson			OS3404-1 I-119 Poock				LECTURE PROGRAM	CS4203 IS0001 IS0810 IS4300 OS3404
WEDNESDAY	CS4203 S-408 Erickson			OS3404-1 I-119 Poock		IS4300-2 I-265 Zweig	IS4300-2 I-265 Zweig		
THURSDAY	CS4203 S-408 Erickson							IS0001 S-321 Bui	IS0001 S-321 Bui
FRIDAY	CS4203 S-408 Erickson								

Students: (1) Nolan Overloads: Fall AY 1992

Figure 6.16 Student Card Sample #2

VII. CONCLUSIONS AND RECOMMENDATIONS

A. THE PRESENT NPS SCHEDULING SYSTEM

The present system for constructing quarterly schedules at the Naval Postgraduate School works well. Scheduling requirements are planned in advance, forecasts are updated and validated, open communications exist between the parties involved in the process, parties receive feedback on their efforts in the form of reports and phone calls, and the resulting schedule is able to accommodate all student course requirements and requests with greater than 99% effectiveness.

The NPS scheduling process is people oriented rather than institution oriented. The school offers students a variety of well-defined, goal-oriented curricula with some degree of latitude in the courses students must complete to fulfill curricula requirements. Students can see the course requirements for their chosen curriculum and track their progress throughout their studies at NPS. Students are participants in the scheduling process, from selecting elective courses to aiding in verifying the accuracy of schedule forecasts. Faculty also have some latitude in how courses assigned to them to teach are scheduled, including being able to choose an alternate number of hours that the course is taught other than the course's credit hours,

selecting required times and rooms for courses, and even requesting personal scheduling preferences.

Automation of some of the scheduling process has played an important role in improving communications between primarily independent parties, providing them with a rapid means of data entry, data verification and feedback via reports. Further automation of other parts of the system can increase productivity and efficiency in those areas. Total automation of the system is undesirable - the human element is an essential part of the NPS scheduling process.

Selective automation can also serve to shore up the foundation of the present system, which relies heavily on the knowledge and experience of a few key people. The present NPS scheduling system relies exclusively on the Class Schedulers for almost the entire Scheduling phase and coordination of the Post-Scheduling phase. The knowledge and experience gained over time regarding the construction of quarterly schedules can not easily be assumed by anyone else should they be unable to perform their scheduling duties. Similarly, the Management Analyst is the only one who knows how to manage the collection of scheduling data for use in the Forecasting and Pre-Scheduling phases and how to produce the results required for scheduling from the computer programs associated with the system.

The following sections examine aspects of each of the four phases of the present scheduling system:

1. The Forecasting Phase

Course needs of both present and future students are planned in advance and the personnel and material resources required to teach the courses are budgeted and acquired during this phase. Forecasting is assisted by an automated Forecast Program, which allows scheduling information accumulated from past quarters to be efficiently and effectively projected to future quarters. The activities of the Forecasting phase lend predictability to the NPS scheduling process and the present process does not need further improvements.

2. The Pre-Scheduling Phase

Forecast scheduling information for the upcoming quarter is validated and updated during this phase. The Curricular Officer is assisted in submitting information about students and their course requests by the FOCUS system. From the entries made to the Curricular Officer Database, the Management Analyst is able to provide a feedback report to the curricular offices in the form of the Curricular Officer Report and to alert departments to updated student course needs via the Department Chairman Report. Following a series of iterations of both reports, a final set of course requests and course offerings is established.

The present Pre-Scheduling phase, while dependent on the Management Analyst, is a well orchestrated and efficient

process, aided by automated data entry, manipulation and reporting. Two improvements are possible:

- A preliminary printout of the Curricular Officer Report can be generated by curricular offices during Week 1 of the phase. The printout can be placed in an appropriate area for students to validate forecast course requests. This step has been implemented by the Computer Technology curricular office with much success. About 100 required or desired course changes are detected at this time that would normally not be detected until after the first iteration is distributed. By that time, departments have already determined their course offerings, which may not meet all student course requests.

- Mainframe terminals or a microcomputer LAN could also be installed in departments that would give them access to the Curricular Officer Report and Department Chairman Report. In this way, they could use automation to complete the third iteration rather than the often ambiguous manual entry method used in the present system. Hardcopy versions of these reports might also be unnecessary, eliminating the need for hundreds of thousands of lines of text and pages of paper being printed each quarter. The Management Analyst could still orchestrate this phase electronically.

3. The Scheduling Phase

During this phase, the Class Schedulers assemble all the scheduling information collected during the Pre-Scheduling phase in the form of hardcopy reports, including over a thousand 5" x 8" cards, and perform heuristic decision-making techniques to construct a Master Instruction Schedule and individual schedules for students, instructors and classrooms/ laboratories. The scheduling process is completely manual. The only automation used in this phase is the report generation capabilities of the FOCUS system, which assists them in assembling and printing the Master Instruction

Schedule, and word processing functions on the microcomputer in their office.

Under the present manual system, the Class Schedulers are working at peak capacity. While there are essential parts of their scheduling duties that can not be easily automated and other parts for which automation is undesirable, much of their time is spent in tasks that can easily be assumed by interactive automation systems. These systems can both increase the scheduling capacity and eliminate much of the unnecessary drudgery of the present scheduling system. The NPS^4 concept is a suggested solution.

4. The Post-Scheduling Phase

Post-Scheduling is the phase where quarterly schedules are maintained and information is collected that aids in future forecasting efforts. This phase is also almost entirely manual. The NPS^4 concept can also help Class Schedulers keep track of schedule changes and may be extended to help provide statistics gathered during this phase.

B. THE CONCEPT OF NPS^4

The Naval Postgraduate School Scheduling Support System (NPS^4) is explained in detail in Chapter IV. Its primary aim is to automate some aspects of the present NPS scheduling process, thereby extending its capacity and creating more system capabilities. The concept is feasible, desirable, sound and achievable at reasonable personnel and monetary

costs. Its potential benefits are many. The requirements and high-level specifications are exhaustively detailed in this research. Design, testing and implementation are the next logical steps.

C. NPS^4 DEVELOPMENT RECOMMENDATIONS

NPS^4 could be developed as an add-on to the present system and operate independent of it, thereby greatly simplifying its development and implementation into the present near-continuous system. NPS^4 is also conceived as incorporating features of the present system so that the program will be instantly recognizable to its intended users (the Class Schedulers), thereby reducing training and transition to this new method of scheduling. Chapters IV and V both detail how NPS^4 does this and alternative ways it can be developed and implemented.

Potential concerns of translating the manual method to an electronic method are addressed, along with potential solutions:

1. Accommodating Two Class Schedulers

Two Class Schedulers perform scheduling at the same time, using interconnected information. This issue has been partially addressed in Chapter V. Either a single microcomputer with dual keyboards and monitors and data-sharing capacity, or two microcomputer systems connected by a LAN to share data, or frequent floppy disk transfers have been

proposed. Since the information the Class Schedulers share is now found on hardcopy reports and not changed, the information could be written onto floppy disks by NPS[4] and inserted into each microcomputer as it is needed. This would be the electronic equivalent of reading the information off a report. Status checks and other written additions to the report could be incorporated into the information on the disks.

2. Viewing More Than One Card at a Time

In the present system, Class Schedulers locate and lay out the schedule cards in front of them so they may visually assess where open periods exist common to all cards and where conflicts between courses occur. This could be accomplished electronically by two methods:

- Electronically locate and display the applicable schedule cards for the course being scheduled with the Instructor Schedule Card in front and the other schedule cards stacked behind it. The tops of the cards, with their identifying information, would be visible, and clicking on any of the cards would bring them to the forefront in place of the Instructor Schedule Card.

- Display a single card with all courses for each period on all the cards, analogous to the cards being transparent and holding them up the the light. In this way, Class Schedulers could easily see which periods were still open for scheduling on all of the cards. Where conflicts exist, displaying a simple X in the conflicting period would be sufficient. When the Class Schedulers hooked the X, the conflicting courses, along with the card identifiers would be displayed in a dialog box.

Figures 7.1 and 7.2 illustrate how these concepts would work:

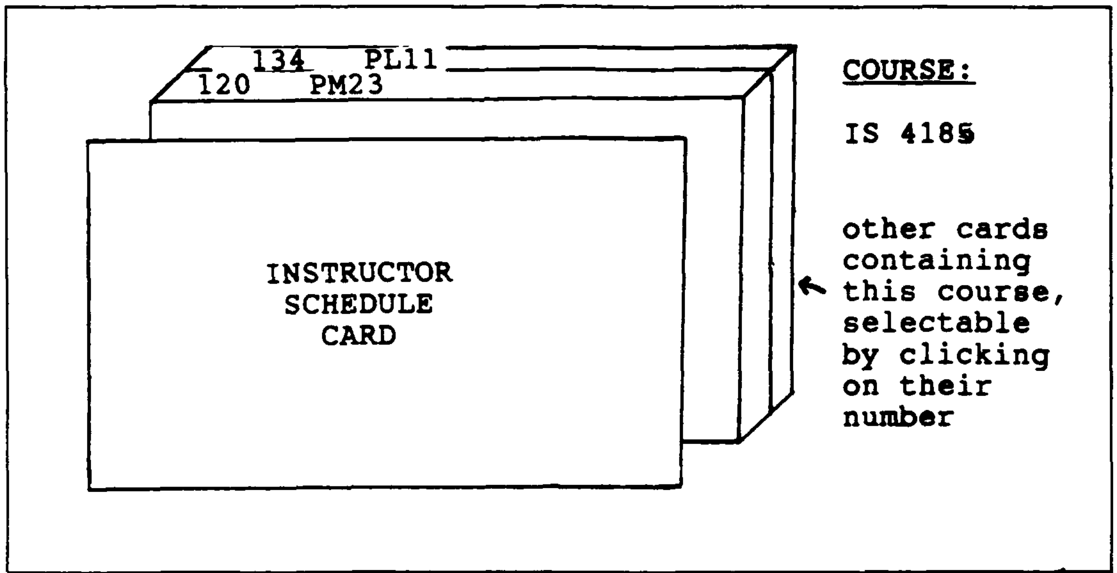

Figure 7.1 Viewing Multiple Schedule Cards Using NPS[4]

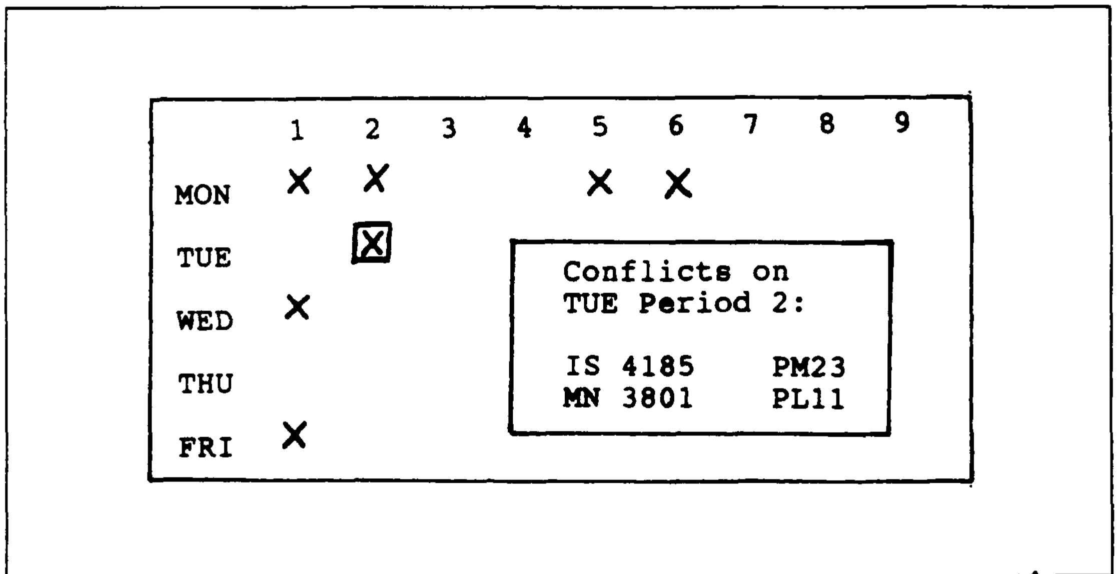

Figure 7.2 Determining Potential Conflicts Using NPS[4]

Two early versions of the project are described in Chapters IV and V:

- a Prototype Version, whereby NPS^4 is operated in parallel with the existing system. This is the recommended version to develop first to aid in further development of the project and to test its capabilities.

- an Initial Version, in which NPS^4 assumes the present tasks of creating all schedule cards and the Class Schedulers use the electronic cards to construct the quarterly schedules. This version could also assist the Class Schedulers in their duties during the Post-Scheduling phase. This is the first version that would have to be formally implemented into the NPS scheduling process and the NPS MIS plan.

Prototype and Initial Versions imply that there are other versions envisioned. In these first versions, NPS^4 is restricted to assisting the Class Schedulers in performing their scheduling duties during the Scheduling and Post-Scheduling phases. NPS^4 can work cooperatively with the FOCUS system to construct the Curricular Officer and Department Chairman Reports, ideally on a microcompter LAN. NPS^4 can also be developed to perform forecasting functions and eventually become the single integrated system used by NPS for its scheduling, employing the FOCUS system strictly as a database manager.

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APPENDIX A

NPS SCHEDULING TERMS AND CONCEPTS

Because NPS scheduling has tended to be a process where individual parties perform their scheduling duties separately and interact via middlemen (either the Management Analyst or a computer), different terms are sometimes used by the individual parties to refer to the same concept or describe the same report, e.g., Department Chairman Report or Department Listing, or segment and section both used to mean a course division. Sometimes the same term is used to mean two separate concepts, e.g., section is used by different parties to refer either to a course or curricular division.

To minimize the confusion, the following list of terms and concepts of the present NPS scheduling process are presented as they have been used consistently throughout this thesis. In most cases, the terms are the same used in official documents. In some cases, though, the terms are created to better distinguish a concept from related ones.

The only reports that are listed are those frequently referred to by more than one name; a description of all reports can be found in Chapter III. Likewise, terms used to refer to NPS[4] and software development, such as object, domain or stochastic are described in Chapter IV and V.

Academic Associate - a faculty member of a curricular program, selected to be responsible for the integrity and academic soundness of the program.

Academic Day - a day of the academic week, divided into nine periods of one hour each.

Academic Group - an association of faculty members, also members of academic departments, who develop courses in an interdisciplinary field.

Academic Week - each Monday through Friday of the quarter.

Academic Year - October of one year through September of the next year, coinciding with the federal fiscal year, divided into four quarters.

Accelerated Course - a course taught in six weeks versus the usual 12 weeks, either from Week 1-6 or Week 7-12; the course is usually taught twice as many periods during the week as its credit hours.

Administration - the military and civilian staff members in charge of operating NPS, including the Superintendent, Provost, Deans and others who oversee the administrative and operational needs of the school.

Classroom Schedule Card - a 5" x 8" card with the schedule for courses held in that classroom during a quarter.

Class Scheduler - the individuals responsible for constructing the Master Instruction Schedule, individual course schedules for students, instructors and rooms, the final exam schedule and for assisting in making changes to the schedule.

Classroom - a room that is used by instructors to teach students course lecture components.

Codes - abbreviated alphanumeric identities by which parties involved in the scheduling process can be referred, e.g. department, faculty, curricula, student section codes.

Convention - a general agreement about procedures to follow when pairing schedule elements; some conventions such as selecting the same number of periods to a course as its credit hours are widely practiced in scheduling, while other conventions are unique to NPS or the particular situation.

Credit Hours - a number assigned to the lecture and lab component of a course that is a measure of the amount of time required to effectively teach the course in a quarter; also called the credits for a course.

CSSO/SSO - Central School Scheduling Officer/School Scheduling Officer - old terms for the individuals who scheduled courses for separate schools at NPS and who coordinated the separate schedules to construct an overall school-wide schedule.

Curricular Officer - a senior military officer in charge of a curricular program who ensures the curricula within the program meet Navy needs and who supervises and directs students in the course of their study at NPS.

Curricular Officer Database - a storage area for information entered by a curricular program's Curricular Officer into the NPS mainframe that primarily includes student-course pairing and curriculum divisional information.

Curricular Officer Report - a hard copy computer report of the information entered into the Curricular Officer Database; also called the Final Iteration.

Curricular Program - one of 11 groups of curricula at NPS related to each other by a common theme, e.g., Computer Technology or Weapons Engineering.

Curriculum - a division of a curricular program that focuses on a specific part of the curricular program's theme, e.g. Computer Science or Information Technology Management in the Computer Technology curricular program. Students select one curriculum to follow during their studies at NPS. Completion of curricular requirements will result in a degree and military subspecialty code.

Curriculum Course Matrix - a matrix of courses and the quarters of the curriculum a student will generally enroll in them that guides students in which courses, during which quarters, and for how many quarters that students will study at in that curriculum.

Curriculum Section - a division of the students who have selected the same curriculum based on the quarter that the students start the associated course matrix and on the degree the students will attain at the completion of the curriculum.

Department - also called an Academic Department to distinguish it from other NPS administrative departments; the entity headed by a Department Chairman and staffed by faculty which is responsible for developing, offering and teaching courses.

Department Chairman Report - a hard copy computer report of the course information entered into the Curricular Officer Database and manually entered by department personnel; also called the Department Listing or Chairman Report.

Engineering Science Course - a type of course taken during a student's refresher quarter, usually for minimal credits, that is intended to provide the student with the necessary technical background for courses they will take when they start their curriculum course matrix.

Experience Tour - a period of study outside the curriculum course matrix. Usually students who are involved in an experience tour will take accelerated courses during one half of the quarter and an experience tour during the other half.

Faculty - members of an academic department who potentially instruct courses; all instructors are faculty, but not all faculty are instructors every quarter - some quarters are spent conducting research or engaged in other academic pursuits.

Final Examination Card - a set of room schedule cards consisting of classrooms in which a final exam can be scheduled; the set of 5" x 8" cards onto which only final exam information is written.

Final Examination Week - the 12th week of every quarter, consisting of Monday through Thursday of that week, during which the Class Schedulers schedule course final exams.

FOCUS System - a collective term for a number of programs, written in the 4th generation database query and report generation language FOCUS, which are associated with collecting, manipulating and reporting scheduling information.

Forecasting Phase - the phase of the NPS scheduling process during which forecasts future course loads and the subsequent faculty workloads and resource requirements necessary to teach the courses; departmental budget allotments are made partly based on reports constructed during the Forecasting phase. The period of time from up to a year or more before a quarter until the beginning of the scheduled quarter.

Group Card - an obsolete term still used to describe a group of courses reserved for a known number of students who will start a specific curriculum course matrix at the same time, but whose individual names are unknown at the time.

Heuristics - self-devised techniques that aid in problem-solving; the method by which the Class Schedulers construct quarterly schedules.

Instructor - a faculty member who is teaching a course.

Instructor Schedule Card - a schedule of the course(s) an instructor has been assigned; a 5" x 8" card containing the instructor's course schedule.

Lab Component - a division of a course that refers to a teaching session where students apply what they learned in the lecture component; the course component frequently taught in a laboratory.

Laboratory - a room with specialized equipment where students apply knowledge they have learned from a course in a classroom; the room in which the lab component of a course is generally taught.

Laboratory Schedule Card - a schedule of the course(s) taught in the laboratory represented by the card; a 5" x 8" card containing the course schedule for this room.

Lecture Component - a division of a course that refers to a teaching session where knowledge is imparted to the students by the instructor, as opposed to the lab component, where the students apply the knowledge they have learned; the course component generally taught in a classroom.

Locator Card - a 3" x 5" card on which students maintain their updated course schedule to enable the Curricular Officer to locate the student any time during the academic day; one of a set of cards kept in the student's curriculum office.

Management Analyst - an information manager who performs forecasting duties and mediates between the Curricular Officers, departments and Class Schedulers during the Pre-Scheduling phase; the individual who employs the computer programs to print many of the reports associated with the Forecasting, Pre-Scheduling and Post-Scheduling phases.

Master Instruction Schedule - the primary end-product report of the Scheduling phase which contains the integrated quarterly schedule; used in conjunction with individual course schedules, which associate names to the numbers of students and faculty codes on this report; may also be called the master or final schedule.

Meetings and Seminars - gatherings of relatively large groups of persons for the purpose of discussing topics more general than or outside the realm of regular course subjects; events that usually have a fixed time to be scheduled during each quarter. Meetings are scheduled on individual schedule cards, but do not appear on the Master Instruction Schedule; seminars usually appear on the Master Instruction Schedule as either scheduled or unscheduled courses.

NPS Scheduling Process - a term referring to the system of procedures, personnel, files, reports and documents that are required to effectively construct quarterly schedules; a four-phased continuous system that deals with pairing students, courses, instructors and rooms to form a schedule.

Period - a one hour long period of time during the academic day; a division of time associated with each course credit hour. Courses are usually scheduled for one period per week per credit hour.

Post-Scheduling Phase - a division of the NPS scheduling process during which the final schedule undergoes changes and statistics are extracted from the schedule to aid in future Forecasting phases; the period of time after the distribution of the Master Instruction Schedule and individual schedule.

Preference - a request from an instructor, usually for a period or room for an assigned course, or a time the instructor prefers not to teach; a request, as opposed to a requirement.

Pre-Scheduling Phase - a division of the NPS scheduling process during which scheduling data is collected about the scheduled quarter for processing during the Scheduling phase; the period of time between the beginning of Week 1 and the end of Week 4 of the quarter preceding the scheduled quarter.

Quarter - a division of an academic year, consisting of 11 weeks of course instruction, the regular instruction period, and a 12th final examination week. There are four quarters in the academic year: Fall, Winter, Spring and Summer.

Refresher Course - a course usually taken by students during their refresher quarter, generally attended by a relatively large number of students. Refresher courses are six weeks long and are taught from during Weeks 6-12, overlapping the final examination week. The course is a relatively non-technical course, as opposed to an engineering science course.

Refresher Quarter - a quarter immediately preceding the first quarter of a student's entering their curriculum course matrix when they generally take refresher and engineering science courses.

Registrar Database - a collection of personal and academic student information kept on the mainframe by the Registrar, for whom the Class Schedulers work; part of the FOCUS system.

Regular Instruction Period - the first 11 weeks of a quarter during which regular courses are taught.

Requirement - a mandatory scheduling factor usually concerning a course or an instructor, e.g., a time or room that the course must be taught to satisfy the course needs.

Scheduling Phase - a division of the NPS scheduling process during which the scheduling information collected during the Pre-Scheduling phase is processed and quarterly schedules constructed; the beginning of Week 5 of the preceding quarter to the beginning of the scheduled quarter.

Segment - a division of a course taught in one room; the segment may be a lecture or lab component.

Senior Programming Analyst - an NPS staff member responsible for maintaining present computer programs and developing new ones; a member of the NPS MIS team.

Student - a person taking a course; a person generally assigned to a curriculum at NPS, except faculty students.

Student Course Group - a group of students in the same curriculum section taking the same group of courses during the same quarter.

Student Schedule Card - a schedule of courses for a student; a 5" x 8" card on which is written a student's course schedule for a quarter.

Subspecialty Code - a military qualification attained by completing a curriculum.

APPENDIX B
HISTORICAL NPS SCHEDULING DOCUMENTS

The following are historical documents used in the NPS scheduling process from 1955-1992. See Chapters II and III for a description of each document. See Appendix C for examples of current versions of some of these documents.

<u>1955-1965</u>

POSTGRADUATE SCHOOL INSTRUCTION 5400.x
[rough draft of NPSINST 5010.3] [Ref.8]
undated (1957) B-3

Instructions for Completing Departmental-Instructor Form
[early version of Department Chairman Report] [Ref.14]
undated (1958) B-7

Engineering School Master Schedule of Instruction
Second Term 1959-1960 . . . . B-9

Recommended Change in Daily Routine memorandum
[proposed change to academic day] [Ref.11]
dated 24 December 1959 . . . . B-10

Segment Size Guidelines memorandum [Ref.12]
dated 10 December 1963 . . . . B-11

<u>1965-1975</u>

Steps In Scheduling [Ref.5]
undated (circa late 1960's) B-12

Final Examination Schedule memorandum
[initiation of final exam week] [Ref.13]
dated 5 April 1966 . . . . B-14

Master Schedule of Final Examinations for
Quarter effective 16-23 May 1966 . . . . B-15

U.S. Naval Postgraduate School Academic Policy
Special Class Schedules [Ref.15]
dated 12 May 1966 . . . . B-16

POSTGRADUATE SCHOOL INSTRUCTION 1520.11A [Ref.18]
Assignment of Section Designators; Procedure for
dated 6 May 1970 . . . . B-17

Naval Postgraduate School
Forecasting, Prescheduling and Scheduling [Ref.3]
undated (1973-1975) B-19

Forecast Schedule [Card] for
Summer Quarter of AY 1973 . . . . B-20

Scheduling Card Program memorandum [Ref.16]
dated 8 June 1973 . . . . B-21

1975-1985

Academic Program [Card]
dated January 1976 . . . . B-22

Special Scheduling Requests
[comments on instructor requirements and preferences]
dated 12 December 1980 . . . . B-23

Statement on Class Sizes
dated 3 September 1981 . . . . B-24

Classroom Utilization at the Naval Postgraduate School
dated 3 September 1981 . . . . B-25

1985-PRESENT

Master Instruction Schedule of the
Quarter effective 30 March-12 June 1987 . . . . B-26

Change in Structure memorandum
[change in NPS organization and department/
instructor codes] dated 16 January 1990 . . . . B-27

Dates for Scheduling Operations for
Quarter III Spring AY 92 [old version] B-29

The Quarterdeck, Vol. 1 Issue 1 [Ref.7]
dated 9 January 1992 . . . . B-30

ROUGH DRAFT

PGS 5400.x (?)
NC4(008)

POSTGRADUATE SCHOOL INSTRUCTION 5400.x (?)

From: Superintendent
To: Distribution List

Subj: Establishment of an Integrated System for Scheduling Academic Instruction at the Naval Postgraduate School

1. Purpose. The purpose of this instruction is to establish an integrated system for scheduling all academic instruction given in the three component schools of the U. S. Naval Postgraduate School.

2. Background. A semi-mechanized scheduling system which involves the utilization of IBM cards and an electronic computer has already been established in the Engineering School. Although this system is still in the developmental stage and requires certain critical steps in the scheduling process to be accomplished by hand, the Superintendent considers that this labor saving method can now be used effectively by all components of the Naval Postgraduate School.

3. Discussion. Beginning with the academic year 1958-1959 there will be extensive cross-utilization of faculty members attached to the Engineering School and the General Line and Naval Science School. To a lesser degree this same situation will also exist in the Management School. Cross-utilization of the teaching staff creates an immediate requirement for some system of integrated scheduling for all three component schools.

The success of this ~~semi-mechanized~~ scheduling system, which stresses mechanization and work simplification, is dependent on the following pertinent factors:

a. Supervision during the initial developmental stage by a mathematician who knows the capabilities of the electronic computer.

b. Appointment of a Central School Scheduling Officer (CSSO) who would have the ultimate responsibility for preparing the master schedule.

c. Close cooperation by School Directors, Department Chairmen and Scheduling Officers (SO) in the three component Schools with the CSSO.

d. Submission of specific raw data by each SO on standard forms provided by the CSSO.

4. Appointment of Central School Scheduling Officer. For the academic year 1958-1959 the responsibilities of the Central School Scheduling Officer are hereby assigned as a collateral duty to Associate Professor H. C. Ayres. In his capacity as CSSO and for this purpose Associate Professor Ayres shall function under the Academic Dean.

5. Action.

a. Responsibility for the collection and processing of required data. The Directors of the three component schools shall be responsible for implementing the following schedule in order to assist the CSSO in his specific task of producing an integrated, master schedule.

(1) Step #1. Ten weeks in advance of the beginning of each term in the Engineering School, each SO shall submit to the CSSO specific information as to numbers of courses and/or curricula, numbers of student groups or sections, size of groups or sections, and other pertinent raw scheduling data. This information shall be submitted on a standard form and in a standardized fashion as indicated by the CSSO.

(2) Step # 2. Not later than the end of the ninth week prior to the beginning of each new term in the Engineering School, the CSSO will make preliminary groupings of students and courses, based on the raw data received from each component School.

(3) Step # 3. Not later than the end of the eighth week prior to the beginning of each new term in the Engineering School, the CSSO shall send the semi-finished data derived from Steps # 1 and # 2 on a second standard form directly to all Department Chairmen.

(4) Step #4. Not later than the end of the sixth week prior to the beginning of each new term in the Engineering School, all Department Chairmen shall complete the standard from provided by the CSSO and return the refined data for final processing. Information contained on this second form will include such data as the assignments of specific faculty members to specific classes, laboratory requirements, time sequence of lectures and laboratory periods, and any other special scheduling considerations pertinent to each course and/or curriculum.

(5) Step # 5. Not later than two weeks prior to the beginning of each new term in the Engineering School, the CSSO shall make available to the Directors of the three component schools the final, integrated master schedule for the forthcoming term. (008 query- in what form?)

(6) Step # 6. The Directors of the three component schools shall then promulgate their portions of the master schedule in whatever form appears best suited to their needs.

b. Procedure for the adjudication of schedule conflicts of adjustments. The CSSO, in consultation with the Director and Department Chairman concerned, will make such adjustments as are necessary and practicable. If major adjustments appear necessary and the problem cannot be resolved satisfactorily at this level, the matter will be referred to the Office of the Superintendent.

c. <u>Responsibility for the distribution of standard forms.</u> Preliminary samples of the forms to be used by the CSSO, SOs and Department Chairmen in connection with the integrated scheduling system prescribed herein will be distributed by the CSSO prior to 1 May 1958. The CSSO shall also insure that sufficient quantities of the standard forms are in the hands of users not later than eleven weeks prior to the beginning of the ~~first~~ each term in the Engineering School for the academic year 1958-1959.

E. E. YEOMANS

Dist:

List #1 plus E-4, G-4, M-4

less E-5, G-5, M-5, V-3

The following is a reproduction of instructions from the Engineering School Scheduling Officer to instructors on how to make instructor requirements and preferences known in an early version of what is today the Department Chairman Report.

INSTRUCTIONS FOR COMPLETING DEPARTMENTAL-INSTRUCTOR LIST

Using enclosure (1), Group-Course List, fill out enclosure (2), Departmental-Instructor List (see sample 2 enclosed), as follows:

COLUMN

1. Courses.
2. Letter designation, only if students in the course are split into two or more classes.
3. Sections or groups taking the course in the class.
4. Number of students, aviators and total.
5. Number of hours class meets for lecturs.
6. Instructor.
7. Room requirement, such as, w/t for with tables, S for Spanagel Hall, R for Root Hall, B for Bullard Hall, etc.
8. Number designation, only if students in the course are split into two or more lab classes.
9. Sections or groups in lab class.
10. Number of students, aviators and total.
11. Total number of lab hours and number of hours each session. For example, 4-2.
12. Instructor.
13 Room.

In addition, as a supplement to this form, submit notes giving all other information pertinent to scheduling, (see sample 1 enclosed).

Submit typewritten original and three carbon copies to the Engineering School Scheduling Officer not later than 13 June 1958.

A. B. MEWBORN
Engineering School Scheduling Officer
Code 0153

SAMPLE 1

NOTES

1. NHlb should have labs in EE 171 ahead of the other sections; NHlb and HLA1. Prefer these labs to follow in close sequence.
2. Lab in EE 171 should come on a an afternoon not concurrent with labs in EE 274.
3. In Es 423 each section should comple its two labs of the week before the next section.
4. Labs in Es 423 and Es 424 cannot be concurrent.
5. Lab in Es 274 should be scheduled in room with desks suitable fo problem work.
6. If convenient, schedule Es 836 so second year students in electoronics E2a, E2b, EA2, can attend.
7. Schedule Ae 163 lab, 8 hours as one full day. If this is not possible, then two afternoons. One-half day morning labs are not desirable.
8. Ae 409 lab is all problem work, requires tables only.
9. EE 711 lab schedule so one hour of free time of the laboratory space be allowed between each two periods of successive use.
10. Es 726 lab do not schedule at the same time as Es 114 lab and no lab space use be scheduled before 1330.
11. Four sections in EE 114 be scheduled consectively with Section EA1 scheduled first in the week. No other labs intervening.
12. Lab in Ma 631 should be on same day as the lecture.
13. Make Tu and Br available to audit Mk's classes in Es 114, <u>lab and lecture</u>.
14. Make Br available to audit Tu's classes in EE 116, <u>lecture only</u>.
15. Pa takes Ph 362 and EE 745 for credit.
16. No classes for Ib on Wednesday afternoon.
17. Mb not available 2nd and 3rd periods on Monday.
18. Xy prefers early classes.
19. Gi requests one hour free for departmental meeting.
20. Ky desires one day free of classes for research and consulting work.

ENGINEERING SCHOOL MASTER SCHEDULE OF INSTRUCTION SECOND TERM 1959-1960

Effective 13 October 1959 until 18 December 59

DAY	GROUP	0815	0905	0915	1005	1015	1105	1115	1205	1250	1300	1350	1400	1450	1500	1550	1600
	A1a	Mc 102	Mb,H-240	Ma 152	Fe,H-246	Ae 211	La,H-223	Ma 158	Mb,H-240	Ae 121		Lab					An,H-125,WI
	A1b	Ma [illegible]	Zu,H-232			Ae 122	Hi,H-125	Mc 102	Ot,S-500								
	[illegible]	Ae [illegible]	[illegible],H-223	Ae 121	Hi,H-125	Mc [illegible]	[illegible],S-504	Ma 158	Lu,S-530	Ae 211		Lab	Cl,H-223				
	[illegible]	[illegible]	Lu,H-125	Ma 156	Lu,S-500	Mc [illegible]	Am,S-310	Ae 211	Kn,H-223					Fly			
	[illegible]	Ae [illegible]	Be,S-310	Ae 502	Hd,H-22[illegible]			Ae 411	Gn,H-125					Fly			
	[illegible]	[illegible]	[illegible]	Ae 502	Gn,S-23[illegible]			Ae 411	Ko,H-221	Ae 316		Lab			Hp,H-221		
	[illegible]	A [illegible]	[illegible]-230	Ae 502	Gr,S-231			Ae 411	Ko,H-221	Ae 316		Lab			Hp,H-221		
	[illegible]			Ae 502	Be,S-231	Ae [illegible]	Kc,H-224			Ae 411		Lab					Ko,PF
	AV2a	EE 771	[illegible],S-506	Ae 502	Hd,H-223	EE [illegible]	Po,S-226	Ae 411	On,H-125	EE 771		Lab	Cl,B-100				
	AV2b	EE 771	Sm,S-501	Ae 502	Va,S-231	EE [illegible]	Vi,S-528	Ae 411	Va,H-224								
	AV2c	EE 771	[illegible],S-506	Ae 502	Hd,H-223	EE [illegible]	Fo,S-226	Ph 361	Oe,S-142	EE 771		Lab	Cl,B-100				
	AZ3	Ph 721	Nb,S-117					Ae 411	Va,H-224					Fly			
	CE2a	Ee 392	Si,S-530	Ee 690	Jo,S-530	Co 261	Lab		Re,B-113			Ee 690		Lab	Jo,B-100		
	CE2b	Ee 392	Ss,S-530	Ee 690	Jo,S-530	Co 221	Rk,B-109										
	EE1a	Ee 212	Mu,S-502	Ma 122	Pi,S-502	Ee 112	Tu,S-502	Ma 124	Ot,S-502					Fly			
	EE1b	Ee 112	Br,S-532	Ee 212	Bm,S-532			Ma 122	Pi,S-532	Ma 124	Ot,S-532						
	EE1c	Ma 122	Lu,S-534	Ma 124	Bl,S-534	Ee 112	Br,S-534	Ee 212	Sh,S-534	Ee 112		Lab			Br,Co,S-431		
	E2a	Ee 298	Bm,S-500			Ee 297	Mu,S-500			Ee 620	Mk,S-500	EE 670		Lab			Bo,B-100
	E2b	Ee 298	Bm,S-500	Ma 392	Ou,S-300	Ee 297	Mu,S-500			Ee 620	Mk,S-500	EE 670		Lab			Bo,B-100
	E2c	Ee 298	Bm,S-500	Ma 392	Ou,S-300	Ee 297	Mu,S-500	Ch 291	Ob,S-228	Ee 620	Mk,S-500						
	E2d	Ee 298	Bm,S-500			Ee 297	Mu,S-500			Ee 620	Mk,S-500	EE 670		Lab			Bo,B-100
	EA2a			Ph 431	Ke,S-140	Ma 321	Bg,S-136	Ee 191	Gi,S-414	Ee 692	Ch,S-530						
	EA2b			Ph 431	Ke,S-140	Ch 401	Cu,B-236	Ee 191	Gi,S-414	Ee 692	Ch,S-530	Ma 421		Lab	Sr,B-240,B-272		
	EA2c	Ph 721	Nb,S-117	Ph 431	Ke,S-140	Ma 321	Bg,S-136	Ma 124	Ot,S-502	Ee 692	Ch,S-530						
	EA3	Ee 305	Mi,S-508	Ee 302	He,S-506	FE 670	St,S-506			Ee 305		Lab			Mi,S-543		
	EN3			Ee 308	Mi,S-508	CE 670	St,S-506	Ee 309	Sm,S-508								
	MA1a	Ph 191	Pi,S-140	Ma 162	Se,S-352			Mr 201	Bd,B-236								
	MA1b			Mr 201	Bd,S-230	Ph 191	Pi,S-142	Ma 162	Co,S-230								
	MA1	Mr 410	Lab		Ta,S-602	Ma 132	Pa,S-208	Mr 413	Ma,S-208					Fly			
	MA2			Mr 415	Mr,B-232	Mr 220	Du,B-246							Fly			
	MM2a	Mr 612	Wk,B-109	Mr 611	Th,B-113									Fly			
	MM2b	Mr 611	Th,S-334	Mr 612	Wk,S-501	Mr 415	Mr,S-228	Ma 421	Ca,B-218					Fly			
	MM2c	Mr 612	Wk,B-109	Mr 611	Th,B-113							Ma 421		Lab	Sr,B-240,B-272		
	MM2d	Mr 611	Th,S-334	Mr 612	Wk,S-501	Mr 415	Mr,S-228	Ma 421	Ca,B-218								
	MC1	ME 502	Le,S-208	CE 701	Ky,S-312	Ch 221	Mc,S-300			Ma 112	Py,S-228						
	MD1a	EE 251	Lp,B-224	Ma 112	Co,S-142	ME 201	Ba,S-224			EE 251		Lab	Lp,B-100				
	MD1b	EE 251	Ki,S-228	ME 201	Ba,S-224			Ma 112	Wa,S-224								
	MD1c	ME 902	Le,S-208	ME 201	Cr,S-208	EE 251	Lab		Pa,B-100	Ma 112	Py,S-228						
MON	MD1d	EE 251	Ma,B-332	Ma 112	Wa,B-310	ME 502	Pa B-232							EE 251		Lab	Mn,B-100
	MM1	Ph 651	Mr,B-231	ME 310	Mo,H-109	ME 512	Mo,B-218	EE 651	Ou,S-352								
	MM2			ME 522	Pr,B-236	ME 711	Ou,H-107	ME 711	Ga,B-107	ME 221		Lab	Pa,B-109				
	MML2a	Ch 105	Wr,B-300			Ma 321	Bg,S-136			ME 210	Wr,B-240						
	MML2b	EE 772	Bm,S-501	Ee 690	Jo,S-530	Ee 248	Bm,S-500										
	MMA2	ME 211	Kz,B-218			ME 512	Mo,B-218			ME 711	Pr,B-107	ME 711	Pr,B-107				
	MJ2	ME 211	Kz,B-218	Ae 902	Va,S-231	ME 512	Mo,B-218			ME 711	Pr,B-107	ME 711	Pr,B-107				
	MLA2	Ma 153	Ot,S-316	EE 472	Wx,S-336												
	MR2	Ph 651	Mr,B-231	ME 310	Mo,H-109	ME 512	Mo,B-218	EE 651	Ou,S-352								
	MNA3			ME 216	Wr,B-240	ME 216	Wr,B-240	ME 812	Pb,B-232								
	MLA3a			ME 674	Pa,B-202					EE 872	Te,B-104	EE 872	Te,B-104				
	MLA3b					EE 674	Tr,S-532	Ph 428	Wl,S-140	EE 872	Te,B-104	EE 872	Te,B-104				
	MR3							Ch 312	Mo,S-300								
	OR	Ph 240	Kb,S-142	Ma 421	Ca,S-136	Ee 399	Mo,S-352	Ch 571	Wl,S-316								
	OP2			Ma 421	Ca,S-136	EE 756	Sm,S-230			Ee 248		Lab			Mo,S-437		
	OO2a	Ae 145	Hd,H-224			EE 674	Tr,S-532	Ma 116	Jo,S-504	Ee 248		Lab			Mo,S-437		
	OO2b	Ae 145	Hd,H-224	EE 674	Pa,B-202	Ee 248	Sh,S-508	Ma 116	Lo,S-506								
	OP2			Ch 416	Bi,S-332	CE 624	Ky,S-312			Ch 800	Ky,S-316	Ch 800	Ky,S-316				
	OR2	Ph 240	Kb,S-142	Ma 421	Ca,S-136	Ee 399	Mo,S-352										
	OU2	Ph 311	Cx,S-136	Ma 421	Ca,S-136			Ph 428	Wl,S-140								
	OX2					Ee 248	Sh,S-508	Ma 116	Lo,S-506	Ph 721	Nb,S-117						
	OO3a	Ch 571	Lab		Mg,Wl,S-331	CE 542	Hg,S-350	Ch 571	Wl,S-350	Ma 351		Lab	Ou,S-008,S-224				
	OO3b					CE 542	Hg,S-350	Ch 571	Wl,S-350	Ma 351		Lab	Ou,S-008,S-224				
	OO3c					CE 542	Hg,S-350	Ch 571	Wl,S-350	Ma 351		Lab	Ou,S-008,S-224	Ch 571		Lab	Mg,Wl,S-331
	OO3d					CE 542	Hg,S-350	Ch 571	Wl,S-350	Ma 351		Lab	Ou,S-008,S-224	Ch 571		Lab	Mg,Wl,S-331
	RO1	Ma 182	To,B-240					Ch 291	Ob,S-228	Ph 341		Lab	Kb,S-141				
	RZ1a	Ph 152	Rk,S-130	Ma 186	Bg,S-520	Ph 635	Ct,S-140	Ee 140	Mo,S-226	Ee 140		Lab	Mo,S-437				
	RZ1b	Ee 170	Tu,S-504	Ma 186	Ob,S-350	Ph 152	Rk,S-130			Ph 635	Ct,S-136			Ee 140		Lab	Tu,S-431
	RZ1c	Ee 140	Tu,S-504	Ma 392	Ou,S-300	Ph 152	Rk,S-130	Ma 421	Ca,B-218	Ph 635	Ct,S-136			Ee 140		Lab	Tu,S-431
	RO2	Ch 202	Ob,B-236	Ch 295	On,S-100	Ch 401	Cu,B-236	Ph 640	Cx,S-138	Ph 425		Lab	Ke,S-140				
	FR2	Ph 311	Cx,S-136	Ch 153	To,S-504			Ph 428	Wl,S-140								
	RZ2a			Bi 800	Ma,S-117	Bi 800	Ma,S-117			Ph 721	Nb,S-117						
	RZ2b	Ph 721	Nb,S-117	Bi 800	Ma,S-	Bi 800	Ma,S-117	Ph 361	On,S-142								
	S1	Ma 122	Lu,S-534	Ma 124	Bl,S-	Ee 112	Br,S-534	Ee 212	Sh,S-534	Ee 112		Lab			Cc,Br,S-431		
	S2	EE 672	St,S-528	Ee 302	He,S-	Ch 401	Cu,B-236										

The following is a reproduction of a memorandum from the first CSSO to the Director of the Engineering School proposing a change in the academic day. Compare this change to the old schedule in the example of the Engineering School schedule.

NC4(015)
24 December 1959

MEMORANDUM

From: Schedule Coordinator
To: Director, Engineering School

Subj: Daily routine; recommended change in

1. It is recommended that the daily routine be changed to contain nine 50 minute instruction periods with the first period beginning at 0810 and the ninth beginning at 1610.

2. The primary advantage to be gained by this change is increased efficiency in utilization of lab spaces. This routine would make it possible to use a lab space for two period sessions as often as fifteen times in a week with the space clear for preparation of material for as least one period between each use. With the present routine each space can be used only ten times in this manner.

3. A secondary advantage to be gained is increased flexibility in schedule construction. Another is the reduction of the peakload on lunching facilities.

4. The ten minute separation between the start of the civil service working day at 0800 and start of classes is considered to be adequate to prevent traffic difficulties on approaches to the school.

5. It is recommended that this change be made effective at the start of the fourth term of the present year.

H. C. Ayres

cc: Dean
Eng School Scheduling Officer

NC4(031)
10 December 1963

MEMORANDUM

From: 03 and 031
To: 51, 52, 53, 54, 55, 57, 59, 61

Subj: Segment Size Guideline

Encl: (a) Forecast Sheets

1. To avoid the difficulties which have arisen in the past due to Department Chairmen using different criteria to determine the number of segments of a course in which the enrollment is large, the following guidelines should be used in preparing the attached forecast sheets.

Number of Students	Number of Segments
$1 \leq N \leq 24$	1
$25 \leq N \leq 47$	2
$48 \leq N \leq 69$	3
$70 \leq N \leq 88$	4
$89 \leq N \leq 105$	5
$106 \leq N \leq 120$	6
$N > 120$	N/20

2. It is requested that Department Chairmen complete their portion of the forecast associated with the attached sheets as soon as possible but not later than 1600 on Friday 13 December 1963.

W. H. PELLETT W. F. KOEHLER

Info copies to:
01
02

The following are the steps used for scheduling in the late 1960's. Compare these with the guidelines and priorities used today in Appendix C.

STEPS IN SCHEDULING

1. During the first week of current term (Term V is an exception) the Scheduling Office supplies the Curricular Officers with an IBM print-out of student programs for the succeeding term. This term print-out will be extracted from the latest forecast. (Forecasts are usually made twice a year, fall and spring). Curricular Officers (8) correct print-outs and return to Scheduling the first day of the second week of current term.

2. Second week of current term is used by Scheduling and Computer facility for extracting Department workloads for the next term.

3. First day of the third week, the teaching workload for Departments is forwarded by Scheduling to Chairmen. Chairmen decide on number of segments for each course, assign instructor to each segment and indicate texts required. The workload is returned to Scheduling the first day of the fourth week of current term.

4. Original (white) is retained by Scheduling for schedule construction and the pink copy is forwarded to the Textbook Library.

5. Prior to schedule construction, review all department submissions digesting special scheduling notes and particularly laboratory requirements, requests for meeting times, blocking of courses, desires of faculty and try to mentally coordinate as many of these requests with scheduling aviators flight time.

6. Try to determine the most difficult courses to be scheduled. Number of sections and students involved in a course is indicative of the degree of difficulty to be encountered in scheduling. Number of hours a special space is to be used is another indication of the difficulty with which scheduling will be accomplished. Schedule the most difficult courses first. Next, schedule "popular" courses at a time interested personnel will be available. Noon is a good time for popular but it kills both wings for aviators for each noon class scheduled.

7. Self contained sections are usually the easiest to schedule, so these are usually left to last.

8. Scheduling consists of bringing together at fixed hours all the sections and faculty members involved, taking into consideration the physical space required and the desires of the faculty members.

9. When class hours have been assigned and you have a consistent schedule, the next step is to assign classrooms to each course scheduled. When assigning classrooms, consider first the location of the students at the previous hour and try to maintain them in the same area the thus reduce traffic between periods. Next, consider the location of the office or previous class of the instructor, and keep to a minimum the distance he must travel between classes. If a choice must be made, and there are no extenuating circumstances, have the instructor move from building to building rather than the students. Try to schedule Department Chairmen as close to their offices as possible.

10. After room assignments have been made, make zerox copies of students and faculty schedules for distribution to Curricular Officers and Department Chairmen, and the Flight Office. End of eighth week.

11. If schedules are acceptable, or if changes have been incorporated, the schedule is written up in rough draft and then typed for printing and distribution. End of ninth week.

12. Schedules are distributed tenth week.

NC4(033)
5 April 1966

From: 03
To: Distribution

Subj: Final Examination Schedule

Encl: (1) Master Schedule of Final Examinations

1. The tenth week of Term IV 16 May through 20 May, has been designated final examination week. During this period two-hour, comprehensive, final examinations will be given in accordance with enclosed schedule.

2. Every effort was made to spread examinations throughout the week, and to block courses having more than one segment at a common time.

3. Requests for changes to the final examination schedule will be submitted to Code 033 stating the reason justifying a change.

J. W. MURPH
Captain, USN
Director of Programs

Distribution:
List 4 less S-1, L, L-1, -2, -3, -4,
C-1, V-3, X
Plus 0332 5 copies

[illegible] SCHEDULE OF [illegible] FINAL EXAMINATIONS
[illegible] 241 (7-65)

EFFECTIVE 16 May 66 - 20 May 66

COURSE	CR HOURS	NO STU	PROF	MONDAY PERIOD	MONDAY ROOM	TUESDAY PERIOD	TUESDAY ROOM	WEDNESDAY PERIOD	WEDNESDAY ROOM	THURSDAY PERIOD	THURSDAY ROOM	FRIDAY PERIOD	FRIDAY ROOM
MR 010			Cq	8-9	E-213								
201			Pc	6-7	~~R-133~~	6 7	R-[illegible]						
203-1			Pl							6-7	R-125		
203-2			Sf			6 7	R [illegible]			6-7	R-125		
206-1			Cl							~~6-7~~	R-123		
206-2			Al			6 [illegible]	[illegible]			6-7	R-121		
211			Du					3-4 R 123A	~~R-216~~				
213			Rd					3-4	R-111				
214			Du					6-7	R-216				
228			Rd							3-4	R-208		
301			Mr					6-7	R-113				
322			Mr			6-7	R-210						
324			Gu	[illegible]	[illegible]	3-4	R 123A	3-4	~~R-208~~				
325			Gu			1-2	R-214						
410			Te			1-2	R-111			3-4			
413			Vb			6 7	R 123A			~~3-4~~	R-222		
810			Te			3-4	S-231						
OC 110			Hc									6-7	R-111
201			Hl	3-4 R [illegible]	~~R-113~~								
211			Gc	~~3-4~~	~~R-240~~					3-4			
251			Gc			3-4	R-240						
260			Jg	3-4	~~R-314~~								
320			Hl			3-4	R-242			1-2			
420			Hc					6-7	Bg 230				
611			Gc			6-7	R-240						
612			Wk	3-4	R-216	3-4 R 1?F							
615			Wk			6-2, 3-4	~~R-216~~						
617			Jg	~~6-7~~ 3-4 [illegible]	~~R-109~~								
700			Al			~~6-7~~	~~R-111~~						
810			Jg			3-4	R-117						
OA 101			Mg							1-2	R-216		
112			Py			3-4	E-211						
141			Sj			6-7	S-332						
218			Ze	6-7	S-248								
234			Sj					3-4	S-202				
235			Tc							6-7	S-208		
291			As	1-2	S-200								
293-1			Cm			3-4	S-502						
293-2			Cm			3-4	S-504						
297			Fo			3-4	S-534						
391-1			Su					6-7	S-502				
391-2			Su					6-7	S-504				
394			Ae					1-2	S-312				
471-1			So									1-2	E 306
471-2			So									1-2	E-307
471-3			Le									1-2	E 322
471-4			Le									1-2	E 322
501-1			Je	1-2	S-226								
501-2			Je	1-2	S-228								
502-1			Pe			6-7	S-532						
502-2			Pe			6-7	S-534						
MA 302			Mh			1-2	S-342						
304-1			Le	3-4	S-224								
304-2			Le	3-4	S-226								
308			Mh							1-2	S 350		
310			Zw									8-9	E 236
311-1			Le					6-7	S-316				
311-2			Mg					6-7	R 238				

PAGE 5

U. S. NAVAL POSTGRADUATE SCHOOL
Monterey, California

NC4(02)/ba
12 May 1966

U. S. NAVAL POSTGRADUATE SCHOOL ACADEMIC POLICY

SPECIAL CLASS SCHEDULES

1. The growth in size of the Postgraduate School faculty and increasing complexity of composing workable class schedules dictate that the tailoring of schedules to individual faculty conveniences is a service that can no longer be accommodated practicably and equitably.

2. Accordingly, requests for special individual faculty consideration in the development of class schedules can henceforth be entertained only in circumstances justifiable on the basis of direct benefits to the U. S. Naval Postgraduate School. Such requests are to be submitted to the Office of the Academic Dean by the Departmental Chairman concerned. The requests should state the bases for the requested exceptions. Direct requests to the Class Scheduler are to be eschewed.

3. Once the class schedule for a term is published, changes in the published schedule will be considered only for intrinsically pertinent reasons which include: resolution of hour or room conflict, provision of a more adequate classroom or laboratory, correction of radical imbalances in class sizes or change of instructor assignment to scheduled courses to provide better instruction or to consolidate faculty schedules. Other alterations in published schedule for faculty and/or student convenience are discouraged, and in no case are to be considered where multiple meetings of a segment on a given day would result.

4. All requested changes in the published schedule are to be communicated directly in writing to the Class Scheduler by the Departmental Chairman concerned. When time is of essence the change requests may be made by the Chairman by phone with subsequent confirmation in writing. Requests justified on bases other than those given above will be referred by the Scheduler to the Dean of Curricula for approval.

R. F. RINEHART
Academic Dean

Dist:
List 1, plus B9 & B10

NAVAL POSTGRADUATE SCHOOL
Monterey, California

NPSINST 1520.11A
NC4(0324)/11
6 May 1970

POSTGRADUATE SCHOOL INSTRUCTION 1520.11A

From: Superintendent
To: Distribution List

Subj: Assignment of Section Designators; procedure for

Ref: (a) Postgraduate School Instruction 1520.11 of 28 January 1969

1. Purpose. To prescribe a revised, standardized procedure for assignment of section designators within curricular programs.

2. Cancellation. Reference (a) is hereby cancelled and superseded.

3. Information. A method of assigning section designators has been established for use in faculty workload forecasting and the scheduling information system that differs from the procedure prescribed by reference (a). With greater utilization of the computer for the above and other academic and administrative processes there is a need for consistency in the method of assigning section designators.

4. Action. Effective with Quarter I of Academic Year 1970-71, the following method of designation will apply:

a. The section designation will be composed of 2 letters and either 2 or 4 numbers arranged as follows:

The first letter designates the section's curriculum as shown:

A Aeronautical Engineering
B Baccalaureate
C Computer Science
D Communications Engineering
E Electronics Engineering
F Nuclear Science Effects
G Advanced Science
H Communications Management
M Management
N Naval Engineering
O Oceanography
P Computer Systems Management
R Operations Research/Systems Analysis
S Engineering Science
U Underwater Physics
W Ordnance Engineering
X Meteorology

The second letter designates the specialty area within the curriculum.

The first number indicates the fiscal year the section commences formal instruction. Refresher period is not counted.

The second number is the academic quarter the section commences formal instruction.

b. If desired, two additional numbers ranging from 01 to 99 may be used to differentiate sub-sections in the same curriculum and specialty who entered school at the same time. There need be no logic behind the assignment of these numbers. They may be used as the Curricular Officer sees fit.

Examples:

RL0401: Operations Research/Systems Analysis, line officer specialty, entered fiscal 1970 Quarter 4 (March 1970), sub-section number 1.

FB11: Nuclear Science Effects, Biology, enters fiscal 1971 Quarter 1, only group in this category

F. H. BURNHAM
By direction

Distribution:
List 1

NAVAL POSTGRADUATE SCHOOL

FORECASTING, PRESCHEDULING AND SCHEDULING

GOAL: Provide advanced technical and professional Education to student Officers to meet the needs of the Navy.

ELEMENTS: Demand Side: Student Officers and Curriculum Officers
Supply Side: Faculty with support personnel and Administrative Staff

OBJECTIVES: Provide education by determination of the Demand Factors:
1) What courses are called by the students Via Curricular Officers
2) How many students are asking for each course
3) When are the courses requested for (In what Quarter)

RESOURCES: What courses and how many segments may be taught in what Quarters based on:
1) Availability of qualified staff to teach the subject
2) How many students are requesting the course
3) In what Quarter and/or sequence will the course(s) be offered

Type of Activities employed to meet the Objectives:

1) FORECASTING is the activity of projecting for several quarters or one or more years in advance the number of students by specialty within curriculum and determining the student demand for courses and the faculty resources necessary to meet this demand.
FORECASTING METHOD: Extension of standard files for future student inputs merged with Academic programs for on-board students using computer program for extensions, merging and printing in several forms of reports.
The Input of forecasting uses the combination of projected Academic Programs for on-board students and standard academic programs with estimated numbers of students by curriculum for future student input.
The Output of forecasting are the projected faculty needs and the Tentative Course Schedule for the current or coming Academic Year.

2) PRESCHEDULING preceeds scheduling and is the activity of determining student demands for courses and the faculty supply of courses for the coming quarter.
PRESCHEDULING METHOD: Several "Iterations" or communications by means of computer printouts between the demand side (Student Officers Via Curricular Officers) and supply side (Academic Departments) using computer programs for editing, sorting and printing.
The Input of Prescheduling is the student academic program form.
The Output of prescheduling becomes the input to the Scheduler and includes:
a) Listing of students section within curriculum showing for what set of courses each student is prescheduled for.
b) Listing of students prescheduled for each course within each department showing their names and curriculum.

3) SCHEDULING follows Prescheduling and is the activity of determining in what classroom and at what time of the day and week students will meet professor for a certain course segment.
The Inputs to Scheduling are:
a) Listing of Students in Section format.
b) Listing of students prescheduled for each course within each Department with segmentation requested by the Department and special requirements (Time and Location of class, etc.)
The Output of Scheduling is the master course schedule for the coming quarter.

M. TROIAN

BS-2301

FORECAST SCHEDULE
TEACHING REQUIREMENTS: CALL FOR COURSES

CURRICULUM

Card code	Last two digits of Academic yr. + Qtr.	Section Desig. / Subsection	Number of Students	Number of Aviators (000)	Course 1 (Department, Course no., Lecture hrs, Lab hrs)	Course 2	Course 3	Course 4	Course 5	Course 6	DST Code	
Y	734	BS2301	001	000	PH3041142	EE2621140	EE2110342	EE2212243			BSBS06	ADAM
Y		BS23[illegible]		000	OC3420333	OS3341140	OS1150020	A02352410				[illegible]
Y		~~BS23~~		~~000~~								
Y		BS23[illegible]		000	OC3115031	MR4411240	OC4321140	MR3220530	MR3225050			
Y		BS23[illegible]		000	CS3111240	PS3012140	OC2110315	MA3233340				[illegible]
Y		BS23[illegible]		000	OS3741140	EE2222333	PS3011240	CS3201140				G[illegible]
Y		BS23[illegible]		000	A02302232	A02303342	A02352410	A0236110				[illegible]
Y		BS2308		000	OC2120(9)0	PS3402140	SP1020240	MN3150490	OS1500020			[illegible]
Y		BS23[illegible]		000	A02302332	A02303342	A02352410	A02381110	OS1500020			[illegible]
Y		BS23[illegible]		000	EE2222232	AE2021132	AE2041132	AE[illegible]	AE[illegible]			

The following is a reproduction of a memorandum from Management Analyst Mike Troian to the Manager, User Services regarding changes to the new Scheduling Card Program:

NC4(0301)/Ii
8 June 1973

<u>MEMORANDUM</u>

From: Administrative Assistant Programs
To: Manager, User Services

Subj: Scheduling Card Program

1. The Scheduling Card Program provides the Scheduler with printed section information on continuous card sheets and was written by Mike Corcoran.

2. The present order of printing is by ascending alphabetic sequence on the first letter of the Curriculum Specialty Codes. The Scheduler would prefer an additional sort on the curriculum office code as shown in the table below.

Curriculum Name	Curriculum Scheduler's Code	All Curriculum Specialties Starting With Letters
Aero	AE	A
BS/BA	BL	B, Y
Elex Com	ES	D, E, H
Mgmt	MN	C, M, P, Q
Meteo & Ocean	MO	O, X
Nav Engr	NE	N
Ordnance	OR	F, G, I, U, W
OR/SA	RO	R
Engr Sci	SC	S

3. This program was first used in April for scheduling of Quarter I, '74 and has permitted printing by the computer of about 700 section cards which were previously hand written. This additional sort would prevent the sorting by hand after the cards are bursted and would make the program more valuable.

4. The next use of this program will be around July 15 for the scheduling of Quarter II, FY74 and it would be appreciated if this modification to the program is made by that time.

5. Thank you for your consideration.

M. Troian

ACADEMIC PROGRAM

Please Send All Changes to Code 0301.
Date Received by Code 0301:

Last Name (Only) | Initials Frst-Midl | Complete Social Sec No | Rank

From: Curriculum Name and Code
Orders to: Specialty and Number
Service: ☐ USN Other: Specify

X For Change	Term No.	Academic Year and Quarter	Curriculum Mail Code	S/D/I Code: Curriculum Specialty Degree Code	Year Input Qtr.	Number of Students	Name-Intls Soc.Sec.No	Course 1 Dept.	Course 1 Course Number	Course 1 Suffix	Course 2 Dept.	Course 2 Course Number	Course 2 Suffix	Course 3 Dept.	Course 3 Course Number	Course 3 Suffix	Course 4 Dept.	Course 4 Course Number	Course 4 Suffix	Course 5 Dept.	Course 5 Course Number	Course 5 Suffix	Course 6 Dept.	Course 6 Course Number	Course 6 Suffix	Yr. Degree Qtr Date	Remarks
	1																										
	2																										
	3																										
	4																										
	5																										
	6																										
	7																										
	8																										
	9																										

Note: 0 = Zero Ø = Alpha O | = One I = Alpha I 2 = Two Ƶ = Alpha Z (Rev. 1-76)

SPECIAL SCHEDULING REQUESTS

1. Background

During each quarter's class scheduling process, special faculty requests come to the Scheduler in three phases: (a) in writing when the departmental teaching assignments are submitted, (b) via individual telephoning after the schedules are distributed, (c) via individual telephoning after the courses have begun. The Scheduler tries to meet all requests and does no "second guessing" with regard to possible influences on educational effectiveness. Requests are unfilled only when student scheduling conflicts preclude implementation.

2. Departmental submissions

The requests typically included in each departmental submission tend to differ consistently from one department to another, viz.,

a. In number, they vary from a relative few per department to anticipatable expression of special needs from every department member.

b. In specificity, they vary from requests for a single non-scheduled time of day or day of week to complete self-schedulings, with no indicated options.

c. The delineation of requests as "required" or "preferred" is uneven, as is the indication as to whether the appropriateness of the requests has been screened by the chairman or his designated representative.

3. Post-scheduling requests

Immediately following issue of individual teaching schedules, there are numerous (typically several dozen) change requests. These fall mainly into two categories:

a. Requests based on newly developed or perceived timing preferences.

b. Requests for Tuesday afternoon rooms, made mostly by instructors with Friday class assignments.

4. Requests following start of quarter

The perhaps a dozen requests typically made during this time frame also fall into two main categories:

a. Requests for room changes, attributable to either larger-than-anticipated class size or unfavorable environmental conditions.

b. Requests for time changes, coming mainly from the small remaining group of Friday assignees.

5. Issue for consideration

Can we, with modest expenditure of effort in faculty orientation and in departmental control and presentation of special requests, effect worthwhile improvements in the overall equity of teaching-time distributions and the quality of the teaching activities.

A. SHEINGOLD
12 December 1980

STATEMENT ON CLASS SIZES

The NPS exists to provide graduate education that is specifically responsive to Navy/DOD requirements for officers with subspecialties in technical and managerial fields. NPS conducts approximately 30 curricular programs within a four quarter, year around academic schedule. Programs range in length from 15 to 27 months and offer single or dual entry times each year to facilitate the detailing of officers in from operational assignments worldwide. The average student has 6-8 years of outstanding service as a military officer prior to entry to NPS. The academic background of each entering student is assessed relative to the specific program he or she is entering. Modifications are then made to the standard program so that full use is made of the individual student's background and the student spends a minimum of time in residence at NPS. With a student body of, say, 1200 there will be on the order of 700 different class schedules each quarter.

Most colleges and universities generate class schedules based on institutional requirements and goals. Because each student has a projected rotation date from NPS and because the military service needs our officer students back for operational assignment, NPS is demand scheduled. That is, the institution schedules in such a way as to meet the requirements of virtually every student each quarter.

The notion of a student section is central to NPS academic operations. Classes may involve one section or pieces of up to 5 or 6 sections. A section is a student input cohort for a specific curricular program and may vary in size from 8 to 25 or 30. For academic planning and faculty budgeting purposes, minimum and maximum class sizes are 5 and 30 respectively. When larger classes are taught it is as a convenience within a given academic department where faculty shortages preclude meeting their teaching requirements with smaller class sizes. In any event, larger class sizes are associated with the preparatory work in early stages of a program and smaller class sizes are associated with graduate elective courses near the end of a program.

The NPS campus is configured with the majority of all classrooms capable of handling 30 or fewer students. Because there are a small number of greater than 30 students taught, and because there are curricular and department seminars involving far greater than 30 students, and because there is requirement for continuing education short courses and conferences involving greater than 30 participants, a shortage of rooms capable of handling 40 to 100 occupants is felt. It is important to clarify that average class sizes however are driven by the nature of NPS academic operations, not the shortage of larger rooms.

CLASSROOM UTILIZATION AT THE NAVAL POSTGRADUATE SCHOOL

The scheduling process at NPS is driven by our unique student "demand" system whereby the Scheduler responds quarterly to course requests for each student received from 11 curricular offices with cognizance over 35 curricular programs. For the Spring 1981 quarter, this involved the generation of 693 discrete schedule sections for 1106 students. In the Fall 1982 scheduling process, currently in progress, there will be 748 sections for 1258 students.

In developing the requisite number of section schedules each quarter, the Scheduler's boundary constraints involve, in addition to the number and size of available classrooms, time constraints that include the preponderance of 4-0 courses, the allocation of a weekly two-hour block for the Superintendent's Guest Lecture, the allocation of one or two hours per week for departmental seminars and/or curricular office usage and the reserving of an hour for lunch between 1100 and 1300 daily. These constraints limit the starting time frame actually available for developing the section schedules to 27-29 hours per week.

In the Spring 1981 schedule, the actual average utilization of rooms for classes assigned by the Scheduler was slightly in excess of 17 hours per week. The deviation of this figure from the 16 hours developed in the First Interim Report of August 14 1981 is attributable to (a) the erroneous inclusion in the data of two rooms, viz., the Lecture Hall I-122 and the special-purpose room R 109, which do not meet the criteria of available classrooms; (b) the scheduling of five additional classes after the Master Schedule was promulgated and (c) the addition of an extra scheduled hour to a number of classes. Not included in the 17-hour computation was the additional classroom usage during the quarter for extra review/problem sessions and for external conferences and meetings.

In developing the Spring 1981 schedule of 693 sections it was found that, as usual, a number of student scheduling requests could not be met. This number typically approximates 6 - 10 students. As in other quarters, the scheduling conflicts were resolved by concerned curricular offices making feasible course delays and/or substituting other courses deemed equally appropriate for meeting program needs. For the Fall 1981 quarter, with an increased number of student sections and an approximately unchanged number of available classrooms, it is anticipated that the number of developed schedule conflicts will increase but that these too will be resolved by course shifts and acceptance of unfavorable but tolerable timing and/or locations for some courses. However, the ability to meet such conflicts in this manner is clearly limited and any significant further increase in schedule conflicts could be resolved only at the expense of effective student programing.

Based on the foregoing considerations, it is recommended that the average weekly room hours (WRH) for planning at NPS be established as a 20 WRH factor. It is believed that this utilization factor can be approached without loss in educational effectiveness, utilizing present scheduling practices. It should be understood that these practices have been specifically designed to meet the particular needs of NPS in carrying out its mission. Hence, no meaningful comparison can appropriately be made between the WRH factor at NPS and those at other educational institutions.

A. Sheingold 9-3-81

MASTER INSTRUCTION SCHEDULE
1260 NPS 5300/5 (1-72)

NAVAL POSTGRADUATE SCHOOL

Monterey, California

SPRING QUARTER AY 87

EFFECTIVE 30 Mar - 12 Jun 87
Final Exam Period 15 Jun - 18 Jun 87

COURSE	CR HOURS	NO STU	PROF	MONDAY PERIOD	ROOM	TUESDAY PERIOD	ROOM	WEDNESDAY PERIOD	ROOM	THURSDAY PERIOD	ROOM	FRIDAY PERIOD	ROOM
ADMINISTRATIVE SCIENCES (CODE 54)													
AS 3611	4-1	32	54WP	3-4	I-271	3-4	I-271	3-4	I-271	3-4	I-271	3-4	I-271
CM 0001	0-2	30	54JS							8-9	I-265		
CM 3111	4-0	25	54JS,ML 55SM			1-2	I-365	6-7 Exam	I-271	1-2	I-365		
3112	4-0	32	54DO	5	S-316	5	S-316	5	S-316			2	S-316
IS 0001	0-2	91	--							8-9	S-321		
2000	3-0	33	54MY	8	I-271	1-2 Exam	I-271	8	I-271			8	I-271
3183-1 3183-2 3183-3	4-0 4-0 4-0	23 23 23	54DK 54AH 54DK	8-9	I-265	1-2 3-4	I-267 I-260	8-9 1-2 Exam	I-265 I-260,263(DK) I-271(AH)	1-2 3-4	I-267 I-260		
4183-1 4183-2	4-0 4-0	40 38	54SJ 54SJ	3-4 6-7 Exam	I-260 I-260,263,271	1-2	I-260	3-4	I-260	1-2	I-260		
4200-1 4200-2	4-0 4-0	30 31	54DV 54DV			1-2 6-7	I-322 I-322			1-2 6-7	I-322 I-322		
4300	4-0	18	54AH	8-9 3-4 Exam	I-323 I-361			8-9	I-323				
MN 0001	0-2	249	--							8-9	I-271		
2112	0-2	15	54WP	8-9	I-285								
2114	0-2	18	54WP					8-9	I-285				
2155	4-0	34	54GK	3 8-9 Exam	I-267 I-386,387	3	I-267	3	I-267	3	I-267		
2302	0-3	39	54SX							6-7	I-260		
3105-1 3105-2 3105-3 3105-4	4-0 4-0 4-0 4-0	19 26 24 22	54RC 54RC 54TH 54TH			1-2 6-7 6-7 6-7 Exam	I-386 I-282 I-271 I-368,369(RC) I-265,271(TH)	8-9	I-119	1-2 6-7 6-7	I-386 I-282 I-271	6-7	I-119
3140-1 3140-2	4-0 4-0	35 37	54SB 54SB	1 4 8-9 Exam	I-271 S-321 I-280,282,285	1 4	I-271 S-321	1 4	I-271 S-321	1 4	I-271 S-321		
3161-1 3161-2	4-0 4-0	32 39	54SM 54SM	1-2 6-7	I-260 I-260			1-2 6-7 3-4 Exam	I-260 I-260 I-280,282,285				
3301-1 3301-2	4-0 4-0	25 25	54ES 54ES			1-2 6-7	I-265 I-265			1-2 6-7 3-4 Exam	I-265 I-265 I-260,263		

DEPARTMENT OF THE NAVY
NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIFORNIA 93943 5100

Office of the Provost

IN REPLY REFER TO
12000
NPS (01)
1 [illegible]

From: Provost
To: Distribution

Subj: CHANGE IN STRUCTURE

1. Effective 1 January 1990 the positions of Dean of Information and Policy Sciences and Dean of Science and Engineering were combined to be one position which is titled **DEAN OF FACULTY AND GRADUATE STUDIES**. This position is being filled by Dean Gordon E. Schacher. To assist Dean Schacher there have been three Associate Deans appointed in half-time positions: Professors Bob Bourke, Jim Eagle, and Larry Jones.

2. Documents which required the signature of either Dean prior to 1 January will now show the title of Dean of Faculty and Graduate Studies with no name included. Signing authority is given to the Dean of Faculty and Graduate Studies or one of the appointed Associate Deans.

3. The mail codes 05 and 06 and the 50 and 60 codes of their associated departments, and the codes 71, 72, 73, and 74 will be discontinued. DRMEC will remain Code 64. The following mail codes will be used:

07	- Dean of Faculty and Graduate Studies Gordon E. Schacher, X3411/3412	
07Bf	- Associate Dean Bob Bourke, X3421/3422	- 68Bf, X3270
07Er	- Associate Dean Jim Eagle, X3421/3422	- 55Er, X2654
07Jn	- Associate Dean Larry Jones, X3421/3422	- 54Jn, x2482
07S	- Support Services Specialist, Jeanne Sells, X3411/3412	

Department and Group Codes:

CS - Computer Science Department
MA - Mathematics Department
AS - Administrative Sciences Department
OR - Operations Research Department
NS - National Security Affairs Department
PH - Physics Department
EC - Electrical and Computer Engineering Department
MR - Meteorology Department
AA - Aeronautics and Astronautics Department
OC - Oceanography Department
ME - Mechanical Engineering Department
AW - Antisubmarine Warfare Academic Group
SP - Space Systems Academic Group
EW - Electronic Warfare Academic Group
CC - Command, Control and Communications Academic Group

RECEIVED
JAN 19 1990

Subj: CHANGE IN STRUCTURE

Each faculty member has an individual code. For individual mail this code will be appended to the department code following a slash, e.g. PH/Z1 = Zeleny in Physics.

It is requested that, for the first six months of this change-over, the new and old code be used, e.g. PH/Z1 (61Z1).

HARRISON SHULL

Distribution:
NAVPGSCOLINST 5605.2M
List 4 Plus D

DATES FOR SCHEDULING OPERATION FOR QUARTER III Spring AY 92

DATES OF THE QUARTER 30 Mar - 12 Jun 92

FINAL EXAM PERIOD 15 Jun - 18 Jun 92

REFRESHERS BEGIN 11 May 92

Friday, 4th week	Receive Chairmen & Curric reports	31 Jan
Friday, 4th week	Send Chairmen & Curric reports to their offices	31 Jan
Wednesday, 5th week	Receive reports from Chairmen	5 Feb
W - F, 5th week	Make changes and complete professor's cards	5-7 Feb
6th week to 8th week	Start to schedule	10 Feb
	Finish scheduling	28 Feb
9th week	Room professors and copy student's cards	2-3 Mar
	Input course data for Master Schedule	4-6 Mar
10th week	Copy professor's cards and schedule finals	9-13 Mar
11th week	Input final exam data and instruction staff list to produce complete Master Schedule	16-17 Mar
	Distribute individual schedules to profs and students	16 Mar
	Proofread the Master Schedule and send a copy to the Registrar for him/her to cross-check.	18-20 Mar
Friday, 11th week	Send to print shop	20 Mar
Wednesday, 12th wk	Distribute schedules (done by mail room)	25 Mar
	Quarter begins	30 Mar

NAVAL POSTGRADUATE SCHOOL • Monterey, California

the navy's university

THE QUARTERDECK

Vol. 1 Issue 1 Jan. 9, 1992

IN THIS ISSUE -

- **NPS move**
- **Bits & bytes**
- **Phone numbers**
- **Rec discounts**

HISTORIC 1951 MOVE

NPS TO MONTEREY FROM ANNAPOLIS

Few outside of the government saw Secretary of the Navy Dan Kimball's December 1951 message that went to all Navy ships and bases.

It was a brief message announcing a change of address for the U.S. Naval Postgraduate School from Annapolis, Maryland to Monterey, California. Kimball's message stated that the new address, or redesignation in Navy parlance, would become effective on Dec. 22, 1951.

It was the final administrative step that brought an official end to a lengthy political stalemate and several years of verbal sparring by Maryland legislators.

The action freed the Navy's graduate university from its cramped quarters at the Naval Academy, and allowed its transcontinental transfer — lock, stock and wind tunnel — to Monterey.

The move, virtually unparalleled in the history of American universities and colleges, affected about 500 people — 370 students, 65 civilian faculty members, 25 Navy staff officers and 25 civil service employees. Several tons of scientific instruments, from microscopes to radars and early computing machines, were transported by railroad and Navy ships to the grounds of the old Del Monte Hotel. Congress had passed Public Law No. 302 in July 1947, appropriating $2.13 million for the Navy purchase of the former world-class resort and more than 600 acres of land to provide a campus for the Naval Postgraduate School.

But, in an attempt to retain the school in Annapolis, Maryland's delegation successfully lobbied against legislation that would provide funds to build the necessary academic buildings for the institution. The political logjam did not begin to clear until Rear Adm. Ernest E. Herrmann took the helm of the Navy university in June 1950.

Encountering a hostile Annapolis business community determined to keep the school in its Naval Academy-based quarters, Herrmann engaged in marathon meetings with local government and business leaders. Before leaving for Monterey, Herrmann would comment: "It is to the great and lasting credit of Annapolis that (the community) has looked upon our departure with kindness and wished us well."

The front of old Del Monte hotel was the site for the official opening of NPS in Monterey. The hotel was later renamed for Rear Adm. E. E. Herrmann, the first superintendent.

In the 40 years since the Naval Postgraduate School's move, the Navy has continued to invest in advanced education. Today's student population exceeds 1,800, more than four times its 1951 figure, and the graduate university now draws military officers from all U.S. uniformed services, civilians employees from the Department of Defense and other government agencies, and officers from nearly 30 allied nations.

The high-caliber institution has attracted other Navy and DOD activities to Monterey, bringing significant increases in professional and technical job opportunities to the Monterey Peninsula and an annual payroll that tops $105 million. With nearly $5 million in local purchases and the revenue generated by the more than 17,000 visitors attending scientific and technical conferences annually at the Naval Postgraduate School, the institution represents one of the top Peninsula businesses.

Exceeding the economic significance

(Continued on page 4)

MLK BREAKFAST

The 6th Annual Dr. Martin Luther King Jr. Prayer Breakfast will be Wednesday. For ticket information, see page 3.

APPENDIX C

PRESENT NPS SCHEDULING DOCUMENTS

The following documents are used today in the indicated phases of the NPS scheduling process. See Chapter III for a description of each document. See Appendix B for examples of historical versions of some of these documents.

ALL PHASES

NAVPGSCOL INSTRUCTION 5010.3B
"Class Scheduling Procedures" [Ref.23]
dated 11 October 1991 . . . . C-4

POSTGRADUATE SCHOOL INSTRUCTION 1520.19
"Assignment of Academic Section Designators
for Scheduling", pending approval [1992] C-8

FORECASTING PHASE

Department of Computer Science
Course Projection - AY92 . . . . C-13

Information Technology Management (370)
Curriculum [Course Matrix]
dated 27 January 1992 . . . . C-14

Computer Science [Curriculum] (368)
Option Area Declaration and Course Selection C-15

PRE-SCHEDULING PHASE

Prescheduling Activities for Winter 1992
(Quarter 2, AY 1991-92) Memorandum C-16

Student Input Sheet for CY 1992
dated 25 July 1991 . . . . C-18

Curricular Officer Report for
Winter Quarter of AY 1992 . . . . C-19

Department Chairman Report for
Winter Quarter of AY 1992 . . . . C-20

Department of Administrative Sciences
Course Offerings, Spring Quarter 1992
dated 21 January 1992 . . . . C-21

Guidelines - Department and Curriculum Listings
Basic Instructions
undated (Winter Quarter AY 1992) C-22

Submission of Spring Quarter AY 1992
Teaching Worksheets
[for third iteration of Department Chairman Report]
dated 31 January 1992 . . . . C-25

Final Iteration of Student Programs,
Spring Quarter, Memorandum
[attached to final iteration of Curricular Officer
Report] dated 31 January 1992 . . . . C-27

<u>SCHEDULING PHASE</u>

Dates for Scheduling Operation for
Quarter III Spring AY 92 . . . . C-28

Guidelines for Setting Priorities for Scheduling
dated 18 January 1991 . . . . C-29

Meetings and Seminars Regularly Scheduled
dated June 1990 . . . . C-30

ECE Lab Rooms [constraint sheet in Binder #1]
dated October 1991 . . . . C-31

E-Z Class Demand Listing
new version with lines [1992] C-32

Student Schedule Cards Color Chart
undated (Winter Quarter AY 1992) C-33

Scheduling Worksheet C-34

Instructor Schedule Card
dated Quarter 2 [Winter] 1991-92 . . . . C-34

Student Schedule Card
dated Quarter 2 [Winter] 1991-92 . . . . C-35

Regular Classroom Schedule Card
dated Quarter 2 [Winter] 1991-92 . . . . C-35

Regular Laboratory Schedule Card
dated Quarter 2 [Winter] 1991-92 . . . . C-36

Final Examination Schedule Card
dated Quarter 2 [Winter] 1991-92 . . . . C-36

Master Instruction Schedule for
Winter Quarter AY 1992 . . . . C-37

Professor Listing for December 1991 . . . . C-38

POST-SCHEDULING PHASE

Change of Registration Form C-39

Scheduling Data for
AY 1987-1992 . . . . C-40

NPS Students Quarterly Enrollment
by Curriculum Specialty C-41

DEPARTMENT OF THE NAVY
NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIFORNIA 93943 5100

IN REPLY REFER TO
NAVPGSCOLINST 5010.3B
NPS (612)
11 October 91

NAVPGSCOL INSTRUCTION 5010.3B

From: Superintendent

Subj: CLASS SCHEDULING PROCEDURES

Encl: (1) Quarterly Calendar of Procedures for the Class Scheduling Operation

1. Purpose. To update information on designating responsibility and indicating procedures to develop class and final examination schedules for the Naval Postgraduate School. To delete paragraph 4c. of the cancelled instruction which was erroneously inserted in the publishing process.

2. Cancellation. NAVPGSCOLINST 5010.3A

3. Discussion. The responsibility for developing the class and final examination schedules is assigned to the Class Scheduler who is assigned the following tasks to be carried out under the supervision of the Registrar:

a. Prepare the schedule for academic instruction for each academic quarter;

b. prepare final examination schedule for each academic quarter;

c. maintain a schedule of use of academic facilities and spaces, and allocate classroom and laboratory spaces as available; and

d. provide the Navy Exchange Bookstore with duplicate copies of department worksheets which list students and instructor for each course.

4. Procedures. Procedures will be carried out according to the timetable indicated in enclosure (1). Attention is drawn to the compact timing involved in the production of the class schedules. Since the class schedule with the attendant assignment of instructors, classrooms, laboratories and textbooks is of vital importance to the successful accomplishment of the school's mission, accurate and prompt submission of the data requested is essential. Additional, general, procedural guidelines follow:

a. Before the beginning of each academic year, the total faculty workload dedicated to teaching is determined by the

Director of Academic Planning, in conjunction with the Department Chairmen, and is based on the forecast of students to be onboard and the courses they will require. The forecast is prepared by the Registrar's Office based upon curricular requirements provided by the Curricular Officers and upon faculty manpower availability provided by the Department Chairmen. The forecast is published in the Tentative Course Schedule for the coming academic year.

b. Class schedules will be prepared using class periods numbered one to nine, scheduled in 50-minute periods from 0810-0900 to 1610-1700.

c. Final examinations are prepared in two-hour sessions Monday through Thursday of the twelfth week of a quarter. Students will have no more than two final examinations scheduled per day; exceptions to this maximum number must be approved by the Dean of Instruction. The final examination schedule may not be changed. The administration of final examinations before the beginning of the twelfth week of the quarter is expressly prohibited.

d. At the beginning of a quarter, requests for changes in the class schedule may be submitted to the Class Scheduler by the Curricular Officers or the course instructors. Changes will be considered only for intrinsically pertinent reasons which include: resolution of hour or room conflicts; provision of more adequate classroom or laboratory spaces; correction of radical imbalances in class size; changes of instructor assignments to provide better instruction or to consolidate faculty schedules; and essential changes in student programs to meet curricula demands. Other alterations in published schedules for faculty or student convenience will be permitted if the change does not adversely affect either the needs of the students or the faculty.

G. K. IVERSEN
By direction

Distribution:
NAVPGSCOLINST 5605.2N
B through B-14, C-1, C-4, D-4, D-14

QUARTERLY CALENDAR OF PROCEDURES
FOR THE CLASS SCHEDULING OPERATION

	ACTION OFFICE			
TIME	CURRICULAR OFFICERS	MANAGEMENT ANALYST	DEPARTMENT CHAIRMEN	CLASS SCHEDULER
WEEK 2	Submit student requests to the FOCUS system for next quarter's courses. Use the Tentative Course Schedule as a guide to indicate the quarter each course is normally taught. At the end of week, receive the first iteration of student requests.	Consolidates data from the Curricular Officers' FOCUS system into a first iteration. This iteration consists of two lists: one, a Curricular Officer report by student and his/her course requests, and the other is a Department Chairman report by course with students requesting each course.	Receive the first iteration and prepare a Summary Listing of courses to be offered or cancelled based on student demand.	
WEEK 3	Receive a Summary Listing from each Department Chairman of course offerings and course cancellations.	Enters course offerings to the FOCUS system and provides a list of student exceptions to Curricular Officers.	Submit the Summary Listing of course offerings to each Curricular Officer and to the Management Analyst.	
WEEK 4	Update student course requests to the FOCUS system to reflect changes in course offerings and course cancellations. Execute student exception list and clear errors. All files must be in order at this time as changes will not be accepted in the Scheduler's Office.	Consolidates data from the Curricular Officers' FOCUS system into the final iteration. This data is based on student course updates. Provides the final iteration to the Class Scheduler.		Receives final iteration and distributes to Curricular Officers and Department Chairmen.

QUARTERLY CALENDAR OF PROCEDURES
FOR THE CLASS SCHEDULING OPERATION

	ACTION OFFICE			
TIME	CURRICULAR OFFICERS	MANAGEMENT ANALYST	DEPARTMENT CHAIRMEN	CLASS SCHEDULER
WEEK 5	Retain the final iteration to properly identify the schedules with the students at Week 11.		Return final iteration to Class Scheduler noting the number of segments for each course, the instructor for each segment, class sessions desired and any designated room or laboratory requirements.	Organizes and prioritizes information noted on the final iteration from Department Chairmen.
WEEKS 6-10				Develops class and final examination schedules.
WEEK 11	Receive schedules from Class Scheduler. Identify schedules with students' names using the final iteration. Distribute schedules to students.		Receive and distribute instructor schedules from Class Scheduler.	Updates scheduling data to FOCUS system to permit access of course and student information to Registrar. Data is formatted into the Master Schedule.
WEEK 12	Receive Master Schedule which indicates instructors and classrooms assigned to all courses.			Publishes and distributes Master Schedule.

NAVPGSCOL INSTRUCTION 1520.19

From: Superintendent

Subj: ASSIGNMENT OF ACADEMIC SECTION DESIGNATORS FOR SCHEDULING

Encl: (1) Specialty-Degree Code Listing

1. Purpose. To prescribe a standardized procedure for assignment of academic section designators within programs for use by curricular offices, academic departments, registrar's office, and scheduler.

2. Cancelation. NAVPGSCOLINST 1520.19; Same Subject

3. Discussion. Academic section designators are used in faculty workload forecasting and the scheduling information systems to identify and differentiate between curriclum specialties. The assignment of section designators has been established to ensure both uniqueness and consistency. Social section designators headed by a section leader may be similar or different.

4. Procedure. Academic Section designators are composed of four two-symbol elements. All four elements may or may not be used depending on specific reporting requirements. The following element definitions will apply:

a. Specialty Code: The first two-letter element identifies the curricular program and the specialty area within that particular program. For example, MV designates the Administrative Science Program (M) and the Material Movement specialty (V) within that program. When a student of a curriculum with subspecialities is in the core part of study, a generic code is used to avoid creating duplicate section(s) having the same courses (for example: OR/SA curriculum).

b. Degree Code: The second two-letter element identifies the degree to be awarded, i.e., MS or MA represents Masters Degree, ED for Engineer, PH for PHD, DM for Dual Masters, ND for No Degree, TR when in Engineering Science, before entering the specialty. Enclosure (1) provides the listing of specialty-degree codes used for scheduling purposes.

c. Input Indicator: The third element is a two-digit number that identifies the academic year and quarter of input. Thus, MVMS23 indicates a section that began instruction in academic year 92, quarter 3.

d. Academic Subsection Indicator: The fourth two-digit element distinguishes between groups of one or more student(s) within the same specialty area that have been assigned one or more different course(s) in a given quarter. MVMS2301, MVMS2302, etc., for example, indicate different academic subsections within the same Material Movement specialty of the Administrative Science Program that began instruction in the same term of academic year 92, quarter 3.

6. Action. Code 611 is responsible for assigning new academic section designators as need arises.

G.K. IVERSEN
By Direction

Distribution:
NAVPGSCOLINST 5605.2L, List 1

SPECIALTY-DEGREE
CODES USED AS OF
FEBRUARY 1992

CODE 30 OR/SA	SPECIALTY DEGREE CODE	CURRICULUM SPECIALTY
GENERIC	RCTR	ENGR SCI
	RCMS	ANY O/R SPECIALTY
360 SUBSPECIALTIES	RAMS	O/R, LAND COMBAT
	RGMS	O/R, AVD MODELING
	RNMS	O/R, NAVAL WARFARE
	RSMS	O/R, SYSTEMS ANALYSIS
	RHMS	O/R, HUMAN FACTORS
	RLMS	O/R, LOGISTICS
	RIMS	O/R, ARTIFICAL INTEL
	RMMS	O/R, MEDICAL CORPS
	FRMS	O/R, ADV MODEL INTEL
361	ROMS	O/R, OPERATIONS LOGISTICS
380	GMMS	ADV SCIENCE, MATH
CODE 31 AERO ENGR SPECIALTIES		
610 VIA460	ACTR	ENG SCI FOR AERO
610	ACMS	AERO ENGR
	ATMS	AERO ENGR FOR TEST PILOTS
611 VIA460	AXTR	ENG SCI FOR AVIONICS
611	AXMS	AERO ELECTRONICS ENGR
CODE 32 ELEX-COMM		
GENERIC 590 VIA460	EXTR	EXTR1 QTR ENGR SCI FOR ANY ELEX PGRM
590	ECTR	2 QTR ENGR SCI FOR ELECTRICAL ENGR
	ECMS	ANY ELECTRICAL ENGR SUBSPECIALTY
SUBSPECIALTIES 590	EAMS	E.E, COMMUNICATIONS SYSTEMS
	EDMS	E.E, COMPUTER SYSTEMS
	EGMS	E.E, CONTROLS
	EPMS	E.E, SIGNAL PROCESSING
	ERMS	E.E, RADAR AND ELECTRO OPTICS
600 VIA460	DCTR	2 QTR ENG SCI FOR COMMUNICATIONS
600	DCMS	E.E, COMMUNICATIONS

CODE 3A ASW/EW	SPECIALTY DEGREE CODE	CURRICULUM SPECIALTY
525	IXTR	1 QTR ENG SCI FOR ASW
VIA460	IETR	2 QTR ENG SCI FOR ASW
525	IXMS	ANTI-SUBMARINE WARFARE
595/6	KXTR	1 QTR ENG SCI FOR EW
VIA460	KETR	2 QTR ENG SCI FOR EW
595	KEMS	ELECTRONIC WARFARE
596	KFMS	ELECTRONIC WARFARE FOR INTL STUDY
CODE 33 WEAPONS		
ANY SPECIALTY	WXTR	1 QTR ENGR SCI FOR WEAPONS ENGR
VIA460	WETR	2 QTR ENR SCI FOR WEAPONS ENGR
530 GENERIC SUBSPECIALTIES	WTMS	ANY WEAPONS SYS TECH SUBSPECIALTY
	WAMS	WEAPONS SYS TECH, AE
	WCMS	WEAPONS SYS TECH, CS
	WEMS	WEAPONS SYS TECH, EE
	WMMS	WEAPONS SYS TECH, ME
	WPMS	WEAPONS SYS TECH, PH
531	WSMS	WEAPONS SYS SCI
532	WNMS	WEAPONS SYS SCI (NVC.P.N)
535	VETR	2 QTR ENG SCI FOR UNDERWATER ACOUSTICS
	VXMS	UNDERWATER ACOUSTICS
CODE 34 NAV ENGR		
570 VIA460	NETR	ENGR FOR SCI NAV ENGR
570	NEMS	NAVAL ENGINEERING
	NTMS	TOTAL SHIP SYS ENGR
CODE 35 AIR-OCEAN	XOTR	1 QTR ENG SCI FOR ANY SPECIALTY
372	XANS	METEOROLOGY
373	XSMS	AIR-OCEAN SCIENCE
374	XTMS	AIR-OCEAN TACTICAL ENRVMT SUPPORT
440	OSMS	OCEANOGRAPHY

CODE 36 ADMIN SCI	SPECIALTY DEGREE CODE	CURRICULUM SPECIALTY
GENERIC	MCMS	ANY A/S SPECIALTY
SPECIALTIES		
813	MVMS	MATERIAL MOVEMENT
814	MTMS	TRANSPORTATION
815	MRMS	PROCUREMENT
817	MAMS	ACQUISITION (ARMY)
	MEMS	ECON (MARINE CORPS)
	MKMS	MANAGEMENT (INTL STUDENTS)
	MOMS	OPS RESEARCH (ARMY)
	MSMS	MGMT SCI (COAST GUARD)
	MXMS	MGMT (CIV FEDERAL PROGRAM)
819	MIMS	INVENTORY
827	MMMS	MATERIAL
837	MFMS	FINANCIAL
847	MPMS	PERSONNEL
CODE 37 COMP TECH		
368	CTMS	COMP SCI VIA 1 QTR OR E/S
	CSMS	COMPUTER SCIENCE
370	PMTR	ENGR SCI FOR INFO TECH
	PMMS	INFO TECHNOLOGY MGMT
CODE 38 NAV INTEL		
681	YCMA	MIDDLE EAST
682	YBMA	FAR EAST S.E. ASIA, PACIFIC
683	YDMA	WESTERN HEMISPHERE
684	YAMA	WESTERN EUROPE
	YXMA	EASTERN EUROPE
688	YQMA	STRAT PLNG, INTL. & NEGOTN
825	YSMA	SCI TECHNOLOGY
CODE 39 C3		
365	JCMS	C3 MANAGEMENT
366	SOMS	SPACE SYSTEMS OPERATION
591	SEMS	SPACE SYSTEMS ENGINEERING

DEPARTMENT OF COMPUTER SCIENCE COURSE PROJECTION - AY92

Course	Name	Hours	Fal	Win	Spr	Sum
CS 0100	Refresher - Beginning Program.	2-1		X		X
CS 0101	Refresher - Laboratory Systems	2-1		X		X
CS 2970	Structured Programming with ADA	4-1	X	X	X	X
CS 3010	Computing Devices & Systems	4-0	X		X	
CS 3030	Principles of Operating Systems	4-0	X	X		X
CS 3111	Principles of Programming Languages	4-0		X		X
CS 3113	Introduction to Compiler Writing	3-2		X		X
CS 3200	Introduction to Computer Architecture	3-2		X		X
CS 3300	Data Structures	3-1		X		X
CS 3310	Artificial Intelligence	4-0	X		X	
CS 3320	Database Systems	3-1	X		X	
CS 3450	Systems Software Design	3-1	X		X	
CS 3460	Software Methodology	3-1	X		X	
CS 3502	Computer Communications & Networks	4-0		X		X
CS 3550	Computers in Combat Systems	3-2	X		X	
CS 3601	Theory of Formal Languages & Automata	4-0		X		X
CS 3650	Design and Analysis of Algorithms	4-0		X		X
CS 3920	Advanced Programming in C and C++	3-2	X	X		X
CS 4112	Operating Systems	4-0	X		X	
CS 4113	Advanced Language Topics	4-0		X		X
CS 4114	Object-Oriented Programming	3-2	X		X	
CS 4150	Programming Tools & Environments	4-0		X		X
CS 4202	Computer Graphics	3-2	X		X	
CS 4203	Interactive Computation Systems	3-2	X		X	
CS 4310	Advanced AI	4-0		X		X
CS 4311	Expert Systems	3-1	X		X	
CS 4312	Advanced Database Systems	3-1		X		X
CS 4313	Advanced Robotics	4-0	X		X	
CS 4314	Symbolic Computing	4-0		X		X
CS 4322	Advanced Database Systems Topics	3-1		X		X
CS 4450	Advanced Computer Architecture	4-0				X
CS 4451	Design & Analysis of Multi-Processor Computers	3-1	X		X	
CS 4470	Advanced Computer Graphics Topics	3-2		X		X
CS 4500	Software Engineering	4-1		X		X
CS 4520	Advanced Software Engineering	3-0		X		X
CS 4530	Software Engineering with ADA	3-0	X		X	
CS 4550	Distributed Computing	4-0	X		X	
CS 4601	Computer Security	4-0			X	
CS 4900	Computer Science Research Seminar	0-2		X		X
CS 4920	Computer Animation	2-2	X		X	
CS 4920	Software Testing	2-2		X		X
CS 4920	Visual Programming	3-2			X	
CS 4920	Physically-Based Modelling	3-2			X	
CS 4920	Virtual Worlds & Simulation Systems	3-2				X

INFORMATION TECHNOLOGY MANAGEMENT (370) CURRICULUM

Revised: January 27, 1992

1st Quarter (Fall/Spring)	IS2000 (3-1) Introduction to Computer Management	CS2970 (4-1) Structured Programming with ADA	OS3101 (4-1) Statistical Analysis for Management	MN2155 (4-0) Accounting for Management
2nd Quarter (Winter/Summer)	CS3030 (4-0) Computer Architecture & Operating Systems	MA1248 (4-1) Applied Mathematics	OS3004 (5-0) Operations Research	MN3105 (4-0) Organization & Management
3rd Quarter (Spring/Fall)	IS4200 (4-0) Systems Analysis and Design	EO2710 (4-2) Introduction to Signals and Systems	IS4183 (4-1) Database Management Systems	IS3170 (4-0) Economic Evaluation of Info. Systems
4th Quarter (Summer/Winter)	IS3020 (4-0) Software Design	EO2750 (3-1) Communications Systems	IS4185 (4-1) Decision Support & Expert Systems	IS4990 (4-0) Research Methods in Information Systems
5th Quarter (Fall/Spring)	IS4300 (4-0) Software Engineering and Management	EO3750 (3-1) Communications Systems Analysis	IS3502 (4-0) Computer Networks: Wide- and Local Area Networks	CM3112 (4-0) Command, Control & Telecommunications Systems
6th Quarter (Winter/Summer)	MN4125 (4-0) Management of Planned Change	NS3252 (4-0) Joint Maritime Strategic Planning	IS4502 (4-0) Telecommunications Networks	Thesis (0-0)
7th Quarter (Spring/Fall)	MN3154 (4-0) Financial Management in the Armed Forces	CS4601 (4-0) Computer Security	MN3307 (4-0) ADP Acquisition	Thesis (0-0)
8th Quarter (Summer/Winter)	IS4182 (4-0) Information Systems Management	Emphasis course (4-0)	Thesis (0-0)	Thesis (0-0)

Notes for international students:

a. Replace CM3112 in quarter 5 with an elective.
b. Replace NS3252 in quarter 6 with IT1500 (American Life and Institutions)
c. Replace MN3154 in quarter 7 with an elective.

COMPUTER SCIENCE (368)
OPTION AREA DECLARATION AND COURSE SELECTION

STUDENT'S RANK AND NAME: ______________________

STUDENT'S SECTION: ______________________

OPTION AREA SELECTED: ______________________

ACAD QTR	NUM QTR	COURSE	COURSE	COURSE	COURSE	COURSE	REMARKS
	4	CS3502	CS3601 OR CS3650			CS4900	
	5	CS4112	CS4202 OR CS4203		NS3252		NOTE: INTERNATIONAL STUDENTS REPLACE NS3252 WITH NS1500
	6	CS3601 OR CS3650		ELECTIVE OR CS4910	CS0810		
	7	CS4601			CS0810		
	8			CS0810	CS0810		

1. STUDENTS ARE ENCOURAGED TO LIST ALTERNATIVE ELECTIVES IN THE "REMARKS" SECTION IN THE EVENT PRIMARY ELECTIVE SELECTIONS ARE UNAVAILABLE.

2. ALL STUDENTS ARE REMINDED TO CHECK COURSE PREREQUISITES AND DEPARTMENTAL COURSE OFFERINGS IN MAKING OPTION AREA SELECTIONS.

____
STUDENT DATE

____
ACADEMIC ASSOCIATE DATE

____
CURRICULAR OFFICER DATE

____
DATA INPUT DATE

NAVAL POSTGRADUATE SCHOOL
MONTEREY,CALIFORNIA

NPS (61)
2 OCT 91

MEMORANDUM

From: Office of Registration and Scheduling
To: Curricular Officers, Academic Associates and Department Chairmen
Via: Director of Programs, Code 03

Subj: PRESCHEDULING ACTIVITIES FOR WINTER 1992 (QUARTER 2, AY 1991-92)

Encl: (1) CY 1992 Input sheet with detailed sheet for "others" dated 25 July 1991.

1. Winter Quarter prescheduling activities will commence on 9 October 1991 and be complete by 30 October 1991.

2. Timetable for Prescheduling:

WED. WEEK 2

a. By COB of 9 October, Curricular Officers are requested to have in their data files the following information for the Winter Quarter:

(1) Individual programs and choice of elective courses for all on-board students, including Fall Qtr 1, AY '91-92 Inputs.

(2) Projected programs for all new input students who will arrive for the Winter Quarter should be included or group cards provided for the Winter Input. Enclosure (1) includes the estimated inputs as of 25 July 1991. Please advise if changes are in order due to more recent information.

Note: Please do not schedule more than a total of (6) courses per student, **including** seminars.

FRI. WEEK 2

b. By 0900 of 11 October: The first iteration of the Chairmen and Curricular Officers Reports will be delivered to them by Mike Troian.

WED. WEEK 3

c. By noon of 16 October: Department Chairmen are asked to have provided Curricular Officers and Mike Troian with a Summary Listing of course offerings, including seminars and reading courses for the Winter Quarter.

FRI. WEEK 3

d. By noon on 18 October: The Winter Quarter Course Offerings will be entered into the data base and an alphabetical list of exceptions will be delivered to Curricular Offices.

WED. WEEK 4

e. By COB of 23 October: Curricular Officers are asked to have updated their files to reflect changes in the student programs resulting from the proposed course offerings and course cancellations. This is the final opportunity to input course changes. THE SCHEDULING OFFICE CANNOT ACCEPT CHANGES. All student files must be in order at this time to be included in the schedule. Please call Mike Troian at extension 2773 if you cannot meet this deadline. Any changes thereafter must be done on the first day of classes in the ~~Fall~~ Winter Quarter.

FRI. WEEK 4

f. By 1000 of 25 October: The final iteration of the Department Chairmen's Reports, Curricular Officers' Reports, and section cards will be delivered to the Scheduler.

WED. WEEK 5

g. By 30 October: The Department Chairmen are expected to submit professor assignments to the Scheduler.

FRI. WEEK 6

3. By the end of the sixth week, 8 November 1991, Curricular Officers are requested to verify their enrollments for possible changes in book orders, particularly for refresher courses for the Spring '92 inputs.

4. a. Curricular Officers are requested to validate the courses for all students in the data base, Winter Qtr. '91-92, against the course catalog by using Option 2.7.

   b. If you have problems with Option 2.7, Please call Mr. Lloyd Nolan at extension X3128.

5. Please call Mike Troian at extension X2773 if you have any questions regarding these procedures.

Tracy N. Hammond
Registrar

ESTIMATED NAVAL POSTGRADUATE :

Curriculum Number and Title	Mode of Input	Estimated Winter '91 USN	OTH	Estimated Spring '91 USN	OTH	Estimated Summer '91 USN	OTH	Estimated Fall '91 USN	OTH	Total Inputs '91 USN	OTH	CY 1991 USN Quota	% of USN Quota
CURR 360	ENG SC	16	1		3	1	13						
OPS ANALS	DIRECT			8	8			3	13	33	38	33	100.00%
CURR 361	ENG SC					8							
OPS LOGIST	DIRECT							8		17		17	100.00%
CURR 365	ENG SC			1		7	8						
JOINT C3	DIRECT				1			3	3	11	13	11	100.00%
CURR 366	ENG SC			3		8	4						
SPACE SYS	DIRECT							4	1	16	8	16	100.00%
CURR 591	ENG SC	6				7							
SP SYS ENG	DIRECT			8				8		21		21	100.00%
CURR 367	ENG SC	18	3			14	5						
EP SYS MGT	DIRECT			10	8			10	14	61	27	61	100.00%
CURR 368	ENG SC	8	1	3		9	3						
COMP SCI	DIRECT			4	8			1	13	21	30	21	100.00%
CURR 372	ENG SC								3				
METEOROLOGY	DIRECT		1								4		
CURR 373	ENG SC	3		4		8	1						
AIR-OC SCI	DIRECT	1		3		1		4		10	1	10	100.00%
CURR 374	ENG SC	3		1		4							
AIR-OC TAC	DIRECT		1	1				1		10		10	100.00%
CURR 440	ENG SC						3						
OCEANOGPHY	DIRECT		1						1		5		
CURR 525	ENG SC	6		1		6		3					
ASW	DIRECT			4				3	2	24	5	24	100.00%
CURR 595	ENG SC					8	1						
EW SYS TECH	DIRECT							8	3	11	4	11	100.00%
CURR 596	ENG SC						4						
INTL EW SYS	DIRECT								8		12		
CURR 380	ENG SC								1				
ADV SCI MATH	DIRECT					4	3			4	4	4	100.00%
CURR 530	ENG SC	3	3			3	7						
WPN SYS SCI	DIRECT			8	5		1	8	8	10	20	10	100.00%
CURR 531	ENG SC	3	1	1		3							
WPN SYS SCI	DIRECT			2				3	1	8	3	8	100.00%
CURR 532	ENG SC					3	1		1				
NUCLR PHYS	DIRECT			5				2		7	3	7	100.00%
CURR 535	ENG SC	3	1			3							
UNDWTR ACOU	DIRECT			3	1				3	7	4	7	100.00%
CURR 570	ENG SC	8	1	11	1	11	8	4	2				
NAVAL ENGR	DIRECT	4		3				4	1	40	13	48	100.00%
CURR 590	ENG SC	4		3		8	4	4	4				
ENGR ELEX	DIRECT	3	3	3	3	3	8	8	11	30	30	30	100.00%
CURR 600	[illegible]			2		3							
COMM ENGR	DIRECT	2	3	1				2	3	10	8	10	100.00%
CURR 620	ENG SC					7	2						
TELECOM SYS	DIRECT						3	10	3	17	8	17	100.00%
CURR 610	ENG SC	3	2	3		8	2		5				
AERO ENGR	DIRECT			4	3			6		24	12	24	100.00%
CURR 611	ENG SC	1		1		1	1						
AVIONICS	DIRECT			3				2		8		8	100.00%
CURR 813													
MATL MOVMNT	DIRECT					4				4		4	100.00%
CURR 814													
TRNSPTN MGT	DIRECT	2				4				6		6	100.00%
CURR 816													
PROCUREMENT	DIRECT	7				16	8			23	8	23	100.00%
CURR 817	VIA 850				1				3				
ADMIN SCI	DIRECT		3				25				30		
CURR 818													
INVNTRY CTL	DIRECT	1				6				7		7	100.00%
CURR 827													
MATL MGT	DIRECT	6				17	4			23	4	23	100.00%
CURR 837	VIA 850				2				1				
FINANCL MGT	DIRECT	14	2			33	8			47	11	47	100.00%
CURR 847	VIA 850				1								
MAN/PER MGT	DIRECT	13	1			17	8			30	10	30	100.00%
CURR 681													
MIDDLE EAST	DIRECT	2	1			2	3			4	4	4	100.00%
CURR 683													
ASIA-PACIF	DIRECT	3	2			3	3			6	5	6	[illegible]
CURR 685													
WESTRN-HMSPR	DIRECT					3	5			3	5	3	100.00%
CURR 684													
EUROPE USSR	DIRECT	3	4			4	8			7	12	7	100.00%
CURR 688													
STRAT PLN	DIRECT	8				8				16		16	100.00%
CURR 825	ENG SC					3							
NAVAL INTEL	DIRECT			6				3		12		12	100.00%
NPS TOTALS	INDIRECT	72	13	33	12	133	62	11	21	249	1?2		
	DIRECT	71	22	70	34	128	70	93	83	350	210	600	
ENG SC-DIR	TOTALS	143	34	103	44	258	148	104	104	588	330	600	100.00%
GRAND	TOTALS	177		147		406		208		938			

Prep 0144A Form Rvsd 7-19-83

CURRIC	SECT	SC	# CLASSES	# NAMES	CLASS	SEGMENT_NO	LECT HR	LAB HR	CNAME		DEGREE	YRGRP
37	PL11	4	5	3	IS4300		4	0				
					MN3154		4	0				
					CS3310		4	0	BOYD	RK	MS	22
					IS0001		0	2	OWEN	JB	MS	22
					IS0810		0	0	RUST	DM	MS	22
		5	5	1	IS0001		0	2				
					IS0810		0	0				
					IS4300		4	0				
					OS3404		3	2				
					CS3310		4	0	WRIGHT	BK	MS	22
		6	5	1	IS0001		0	2				
					IS0810		0	0				
					IS4300		4	0				
					MN3154		4	0				
					CS3320		3	1	BEERNINK	KA	MS	22
		7	5	1	IS0001		0	2				
					IS0810		0	0				
					IS4300		4	0				
					MN3154		4	0				
					CS3550		3	2	YOUNGBLOOD	PD	MS	22
		8	5	1	IS0001		0	2				
					IS0810		0	0				
					IS4300		4	0				
					MN3154		4	0				
					CS4202		3	2	BRANLEY	WC	MS	22
		9	5	1	IS0001		0	2				
					IS0810		0	0				
					IS4300		4	0				
					OS3404		3	2				
					CS4203		3	2	NOLAN	JS	MS	22
		10	4	1	IS0001		0	2				
					IS0810		0	0				
					IS4300		4	0				
					CS4601		4	0	DEFORD	DF	MS	22
		11	5	1	IS0001		0	2				
					IS0810		0	0				
					IS4300		4	0				
					MN3154		4	0				
					EO3750		4	0	FOSTER	TA	MS	22
		12	5	1	IS0810		0	0				
					IS4200		4	0				
					IS4300		4	0				
					MN3154		4	0				
					IS0001		0	2	PENCE	TB	MS	22

BTOT LECT LAB SECT ESTL

DEPARTMENT CHAIRMAN REPORT FOR DEPT AS
10/24/91 YEAR 92 QUARTER 2

NUMBER OF SEGMENTS: 1 PROFESSOR: Dresser AS/Dr ROOM

AS1201 6 4 0 CSPH01 1 CHUANG, S

CS2301 5 HARIRANTO ES HILARIS, A LAZARIS, K SERBEST/SAHI

Prefers 0800 - 0900 or 0900 - 1000

1 hour classes
Final - no
Oral presentations
Requires a room with movable tables and chairs

NUMBER OF SEGMENTS: 4 PROFESSOR: Dresser AS/Dr ROOM

AS2701 6 4 0 FA0402 1 CHE, JP
~~MK1101 1 LEE V~~
MK1102 1 DILEK CA
MK1301 1 LEE P
MK2201 2 [illegible] [illegible]

2 hour classes
Final - No
Writing project

[illegible] Horton AS/Hn

[illegible] 15 [illegible] [illegible] [illegible]

Prefers 1200 Mon - Thurs

CHANG, T FERGUSON, [illegible] [illegible]
HOWARD, [illegible] [illegible] [illegible]
OLMANS, SH [illegible] [illegible]
[illegible] [illegible] [illegible]

1 hour classes
Final - Yes

NUMBER OF SEGMENTS: __ PROFESSOR: ______ ROOM ______

CM0001 27 0 2 DC1101 1 DL PA
~~Dan Boyer~~
DC1102 1 BOUGIOUKOS, G
EA1101 1 LEMOS, P
~~HM1101 8 APOLLO, RA HEADLES, JH~~ BENEDICT, [illegible] CHUI, NJ
KUAN, HI RILEY, JH PUSST, JF [illegible]
HM1102 1 WORRELL, CA
HM1103 12 JENNETT, PD CAIN, [illegible] [illegible] [illegible]
ESTEN, CM GAFFEY, MA LARKEY, JJ MCGRATH, SJ
MORALES, RC RAND, AL [illegible] [illegible] [illegible] TA
HM1104 1 ALEXANDER, IH
HM1105 1 HAPKLER, AL JR
HM1106 1 [illegible] MS

NAVAL POSTGRADUATE SCHOOL
Monterey, CA 93943-5000

NPS(AS/Hr)
21 JAN 92

MEMORANDUM

From: Chairman, Department of Administrative Sciences
To: Curricular Officers/Academic Associates
Department Chairman

Subj: COURSE OFFERINGS, SPRING QUARTER 1992

1. The following courses will be offered by the Department of Administrative Sciences for the Spring quarter (beginning Monday, 30 March 1992):

AS 1701	MN 2302	MN 3902
AS 3611	MN 2303	MN 4105
IS 2000	MN 3105	MN 4106
IS 3170	MN 3111	MN 4111
IS 3183	MN 3140	MN 4145
IS 4183	MN 3154	MN 4151
IS 4200	MN 3161	MN 4302
IS 4300	MN 3172	MN 4310
IS 4320	MN 3301	MN 4371
IS 4800	MN 3303	MN 4376
MN 2112	MN 3305	MN 4761
MN 2155	MN 3371	MN 4900

2. The following courses will not be offered during the Spring quarter:

AS 2701	MN 2150	MN 4162
CM 3112	MN 3373	MN 4163
IS 0123	MN 3374	MN 4373
IS 4186	MN 3377	MN 4500
IS 4502	MN 4125	MN 9999
IS 4925		

REUBEN HARRIS
Associate Chair for Instruction
Administrative Sciences Department

Dist: Codes 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 3A
Codes CS, MA, AS/Bd, AS/Bo, AS/Eb, AS/Ev, AS/Fm, AS/Hr, AS/Lt, AS/Mg, AS/Sa, AS/Th, AS/Wp, OR, NS, PH, EC, MR, AA, OC, ME, AW, SP, EW, CC

GUIDELINES

DEPARTMENT AND CURRICULUM LISTINGS

BASIC INSTRUCTIONS

Prior to Scheduling

On Friday of Week 4, M. Troian brings all the Department Listings, Curriculum Listings, and the Student Section Cards to the Scheduling Office.

1. We separate the Listings by Department, and Curriculum Office, marking the appropriate curriculum number or department code on the copies we keep - **for our office**. (Also noted on our copies are the current Qtr and Year, such as, Winter Qtr, AY 92/2 on the lower portion of these Listings.)

2. The Academic Departments get one department course listing (on plain computer paper/a working copy), and a department course listing with two attached carbon copies. The two top carbon copies (the face copy/original plus one copy for the Bookstore) are returned to us by Wednesday of the following week.

3. We attach a corresponding Memo for each Department Listing and also for all the Curriculum Offices Listings. We send these to the departments and curriculum offices via M. Troian.

4. In addition to the course Listings sent to Dept. and Curric. offices, we also prepare a plain computer paper printout copy for the scheduling office, marking it appropriately as noted in item 1.

THE FOLLOWING RESTATES WHAT MIKE T. BRINGS TO THE SCHEDULING OFFICE ON FRIDAY - WEEK 4 OF THE QUARTER.

EXAMPLE:

A. Curricular Office printout, or listing (Final Iteration)

2 copies on plain computer paper
1 copy - keep
1 copy - separate into currics., attach memo, deliver to Curric. offices.
(M. Troian will usually deliver.)

B. Department Chairmen printouts

2 Copies on plain computer paper
1 copy - keep
1 copy - (their working copy), separate by dept.,
attach memo, delivered to Dept. with 3-part copy.
(M. Troian will usually deliver.)

1 copy on three-part (green lined) paper

Separate into departments (keeping three-parts together).
Deliver to dept. with the above mentioned plain working copy. We do not keep any of this copy. It is the one returned to us the following week. (The department will keep the back carbon.)

Our copies of the plain computer paper printout are broken down by curriculum and department to make changes and study.

C. Student Section Cards

Student section cards are separated by curriculum and sent to the print plant to be trimmed, (all the same size) and smooth edged. After trimming, we add the Curriculum top/face card to each curriculum group and color code the group. We use the same colors each quarter. All the seminars are then written on the student cards.

At this time, before we actually start scheduling classes, any change of student courses must come from a Curricular Officer, or an Academic Associate or possibly from a Dept Chairman. These are special or unique cases. Note any change in 3 places; in the Curricular Office Listing printout, on the student's section card, and after the course in the Department Listing printout.

Checking the Section Cards

(If time allows, cards can be checked before they are taken to the Print Plant.)

Section cards have two specific identifications. The first is numerical by pre-designated printing order of curricular offices (EX: Aero Engr/code 31 is first). The lowest number is the first card in this order, and the highest number is the last card in this printing order (which is Wpns Engr/code 33)

The second identification is the Section Code. The Section Code is always a combination of two (2) letters followed by four (4) numerical digits. The 2 letters indicate the curriculum of the student and the first digit of the 4 numbers indicates the year the student/s comes on board, the 2nd digit represents the academic quarter of that year. The last 2 digits show the printing order for that particular(unique) schedule. *(Note: In some instances the first two numerical digits may indicate the year and quarter the student is actually earning credit.)*

EXAMPLE:

MS 2301

MS = Management Science/Coast Guard
2 = 1992 (the year)
3 = Quarter 3 or Spring Quarter
01 = The first MS student for 1992-Qtr 3 entered for a specific and unique combination of classes (a schedule)

We check the Section Cards for any discrepancies in the print order, for instance, the first card should be number one, 1, and if it is not, an error may have happened, and we need to follow it up. We also look for the newest students in each curricular office section.

Marking those who may have any unusual course combinations. The other cards we are interested in are those with EX 0001 as a course. This indicates they will be taking an experience tour and their classes will be accelerated. We are also interested in noting any cards showing refresher courses with regular courses on their schedules. To recognize these types of schedules right away can save us much time and unnecessary problems later on. These courses will take a high priority in our scheduling order.

We can look for these things when the section cards arrive, if time permits, or when we are color coding the section cards and/or when entering the seminars on the section cards.

STUDENT SECTION CARD ___ Class Schedules Entered On This Card

1st - 9th Periods-->

1	2	3	4	5	6	7	8	9
8:10-9am	9:10-10am	10:10-11 am	11:10-12pm	12:10-1pm	1:10-2pm	2:10-3pm	3:10-4pm	4:10-5pm

WHEN CARDS ARRIVE FROM MIKE TROIAN:

1. Separate by Curriculum, and Section Number in numerical order lowest number on top.
2. Place as first card, a face card with Curriculum Name and Number on it. Band each Curriculum separately with a rubber band.
3. Bring to Printer to trim evenly, all Curriculum cards to be the same size. (Attach Sample.)
4. When returned - Color Code - use same colors previously used for a particular curriculum.
5. Write in all Seminars - using Dept. listings to verify students and the count of class. (Total size/number of Enrollment)
6. Check off seminar and thesis course numbers in the course listing on this card.

NAVAL POSTGRADUATE SCHOOL
Monterey, California

NPS(612)
31 JAN 92

MEMORANDUM

From: Scheduler, Code 612
To: Department Chairmen

Subj: SUBMISSION OF SPRING QUARTER AY 1992 TEACHING WORKSHEETS

Ref: (a) NAVPGSCOLINST 5010.3B

1. The attached worksheets are a compilation of your department courses for next quarter. As per reference (a), it is requested that the worksheets be returned to the Class Scheduler noting the following on each course:

a. **Indicate** the number of segments.

b. **Indicate** the Dept/Professor Code with the instructor's name.

c. **Indicate** any special rooms **required** for classes or labs such as those with special equipment or instructional aids. Please **indicate** room number in the space provided on the Listing.

Indicate any special hours for lectures and/or labs.

- accelerated classes (1/2 quarter, 1st or 2nd six weeks?)
- labs such as 0-4, 0-6 (two-hour labs?). **Indicate** if a lab should not conflict with other labs due to equipment or lab technician requirements.
- two-hour block lectures required?

EXAMPLE:

DEPT CLASS #TOT LECT LAB SECT #STU

NUMBER OF SEGMENTS _2_ PROF: HAMMING/CS/HG RM: S-421 **REQUIRED**
(for equip) Prefers mornings
LAB S-311 **REQUIRED**

CS	CSXXXX	50	4	1	CS1234	1	SMITH
					PL1234	1	JONES
					etc.	1	etc.

---

d. Indicate if course will have an unscheduled (project, paper, etc.) final exam. The Class Scheduler is to be informed of any unscheduled exams at the time of pre-scheduling. Courses with a term project or a term paper will be unscheduled for final exams. Oral exams and take-home exams will be unscheduled also, but should be administered during the twelfth week. Please indicate if any of these examples applies to your Department's courses.

It is not necessary to show verbatim the requests of instructors. Precise information, however, is needed. If any request is unclear, please ask the instructor to clarify. If an instructor states a specific requirement - that is not self-explanatory, we need to know **WHY** it is required. This knowledge saves telephoning the Dept., and/or instructor for more information.

2. In addition, the department notes should include a list of any required scheduling constraints; for instance, (a) regularly scheduled department meetings and seminars and, (b) any professors who need to attend other NPS academic meetings during the quarter. Please list by professor and meeting.

3. Please complete the 3-part Department Course Listing with necessary data, and hand carry the original (the front or top copy) of the three-part (lined) Dept Listing, plus one carbon copy, along with the department notes to the Scheduler, Herrmann Hall, Room 159, as soon as possible but not later than 0900, Wednesday, 5 FEB 1992. (Retain the back copy of the 3-part Listing for the Departments' record.)

EDITH PHILLIPS
SCHEDULER

The following is a reproduction of a memorandum from the Class Scheduler to Curricular Officers, typically attached to the final iteration of the Curriculum Officer Reports.

NAVAL POSTGRADUATE SCHOOL
Monterey, California

NPS(612)
31 JAN 92

MEMORANDUM

From: Scheduler, Code 612
To: Curricular Officers

Subj: FINAL ITERATION OF STUDENT PROGRAMS, SPRING QUARTER AY 1992

1. The attached data is the final iteration of your student programs for prescheduling for the Spring Quarter AY 1992.

2. As noted in the Registrar's pre-scheduling memo of 8 Jan 1992, the Scheduling Office will not make any changes to this iteration. Required changes will be accepted by the Registrar's Office on "Change of Registration" forms beginning the first day of the Spring quarter.

3. Save this final iteration because it is your only means of matching the students with their section schedules when the schedules are distributed during the present quarter's eleventh week (approximately 16 March).

EDITH PHILLIPS
SCHEDULER

DATES FOR SCHEDULING OPERATION FOR QUARTER	III Spring	AY	92
DATES OF THE QUARTER	30 March - 12 June 92		
FINAL EXAM PERIOD	15 June - 18 June 92		
REFRESHERS BEGIN	11 May 92		

FRIDAY, 4TH WEEK	RECEIVE CHAIRMEN & CURRIC REPORTS	31 Jan
FRIDAY, 4TH WEEK	SEND CHAIRMEN & CURRIC REPORTS TO THEIR OFFICES	31 Jan
WEDNESDAY, 5TH WEEK	RECEIVE REPORTS FROM CHAIRMEN	5 Feb
W - F, 5TH WEEK	MAKE CHANGES & COMPLETE PROF'S CARDS	5-7 Feb
6TH WEEK TO 8TH WEEK	START TO SCHEDULE FINISH SCHEDULING	10 Feb 28 Feb
9TH WEEK	ROOM PROF'S & COPY STUDENT'S CARDS. INPUT COURSE DATA FOR MASTER SCHEDULE	2-3 Mar 4-6 Mar
10TH WEEK	COPY PROF'S CARDS & SCHEDULE FINALS	9-13 Mar
11TH WEEK	INPUT FINAL EXAM DATA & INSTRUCTION STAFF LIST TO PRODUCE COMPLETE MASTER SCHEDULE. DISTRIBUTE INDIVIDUAL SCHEDULES TO PROFS & STUDENTS. PROOFREAD THE MASTER SCHEDULE & SEND A COPY TO THE REGISTRAR FOR HIM/HER TO CROSS CHECK.	16-17 Mar 16 Mar 18-20 Mar
FRIDAY, 11TH WEEK	SEND TO PRINT SHOP	20 Mar
WEDNESDAY, 12TH WEEK	DISTRIBUTE SCHEDULES (DONE BY MAIL ROOM)	25 Mar
QUARTER BEGINS		30 Mar

GUIDELINES FOR SETTING PRIORITIES FOR SCHEDULING

The following is a guide for establishing scheduling priorites for courses:

1st	Schedule department meetings, council, and committee meetings for professors; and curriculum seminars and the Superintendent's Lecture for the students.
2nd	Schedule refresher courses - require large rooms and the scheduling dates extend into final exam week.
3rd	Schedule courses which have required times (i.e., computer networks-OS 3404, current weather products-MR 3235, and tide conditions-OC 3120).
4th	Schedule courses which have required times and days for professors (i.e., research and travel constraints, teaching at other universities).
5th	Schedule courses which have a <u>large number</u> of students. NPS has a limited number of large classrooms therefore, room scheduling demands a high priority.
6th	Schedule courses taught by Dept. Chairmen and Deans.
7th	Schedule any two courses that must be scheduled at the same time (i.e., MR 3250 & 3252, EC 4610 & EC 4620).
8th	Schedule accelerated courses. These courses are normally scheduled for double the course hours. The courses are usually accelerated to allow the specific group of students time for an experience tour.
9th	Schedule courses with two or more segments which require designated students be placed in the segments.
10th	Schedule courses requiring special rooms (i.e., computer terminals, NSA map rooms, classified rooms).
11th	Schedule courses which require three-hour labs.
12th	Schedule courses that use the same lab rooms and cannot conflict in time or with lab technicians (i.e., electrical engineering and physics labs).
13th	Schedule courses with a large diversity of majors.
14th	Schedule professors with 3+ classes or team-teaching.
15th	Schedule remaining classes.

MEETINGS AND SEMIN[AR]. REGULARLY SCHEDULED

	1 0810-0900	2 0910-1000	3 1010-1100	4 1110-1200	5 1210-1300	6 1310-1400	7 1410-1500	8 1510-1600	9 1610-1700
MON	Choose one hour after schedule is completed: PH 0499 + profs; SSAG 1 hr, Save I-362 M-Th 6-8th pds for English classes for Code 0305 Save S-429 Th 8th & 9th for Signal Processing Mtg, Code 62TI Save R-208 Th 8th & 9th for Operational Logistics Seminar, Code 55SO				Faculty Exec. Board		CHAIRMEN AND DEANS' MEETING		
TUE				SS 4000 (SO&SE+62PZ) S-421				C3 Group Mtg ·CS Dept Mtg MR Dept Mtg ·ME Dept Mtg, H-201F ·AA Dept Mtg MA Dept Mtg, I-381 ------SGL--------	
WED				AE 4000 (AE+AE profs) S-421			·ASW Mtg	Academic Council OR Dept Mtg & Seminar R-260	
THU				ME 0951 (NE+ME profs) S-421 PH Dept Mtg EC 0950 (+ EC profs) S-231		·OC Dept Mtg MN 2302 - I-260		Faculty Council I-260 OA 0001, R-202 (OA) CS 0001, S-321 (CS) IS 0001, S-321(PL)54DK MN 0001, I-271 ·EW 0002, S-421(KE,EW)profs CM 0001, I-265(HM)54B0 ~~NSA Dept Mtg, R-204A~~	
FRI		EW Group Mtg		PH 0999 (+ PH profs) S-117				MA Dept Colloquium, I-322 ·AS Dept Mtg ST 0001, S-231 (IX)+ASW Grp ·CC 0001, S-117 (C3)+C3 Grp	
	1 0810-0900	2 0910-1000	3 1010-1100	4 1110-1200	5 1210-1300	6 1310-1400	7 1410-1500	8 1510-1600	9 1610-1700

SCHEDULING WORKSHEET 12ND NPS 126 (5-60)

ECE LAB ROOMS Oct 1991

B-100A EC 2800 (conflict ok for Prof. Terman), EC 3800

B-201 Group

C. CIRCUITS-----EC 2100, EC 2110, EC 2150, EC 2170

D. DIGITAL------EC 2810, EC 2820

E. ELECTRONICS--EC 2200, EC 2210, EC 2220 (conflict ok for Prof. Ewing), EC 2250

S. SIGNALS------EC 2500, EO 2710, EO 2750, EO 3750, EO 4720

B-208 CONTROL----------EC 2300 (conflict ok), EC 3310, EC 4330, EC 4340, EC 4350, EO 2730

B-224 OPTICS-----------EC 3210, EC 3550, EO 4730

S-303 VLSI-------------EC 3820 (if Prof. Terman, conflict o.k.) EC 4870

S-419 MICROWAVE--------EC 2610 (3-1 course but usually request a 2 hr lab. If segmented the 2 hour labs may be at the same time) EC 2650, EC 3600 (conflicts ok; if it is Prof.Knorr's lab, show as unsch.), EC 3610, EC 3620, EO 2770, EO 2760, EO 3720, EO 3760, (uses S-703 also) (conflict ok if Prof. Knorr)

NOTE; S-703 Labs should not conflict with S-543/545 labs (running operational radars on roof)

S-431 PC LAB - EC 3400, EC3420, EC 3440, EC3820, EC 3830, EC4420, EC 4440

S-543 RADAR, ROSS SEELY (no more than 15)
EC 3670, EC 4610 (3 hours), EC 4620 (3 hours), EO 4760

S-612 EW LAB, ROSS SEELY (this lab not to conflict with S-543)

EC 4670 (3) If both taught, schedule labs
EC 4680 (3) and lectures together.

EC 4690 (3)
EO 4780 (3)

Schedule a CLASSROOM for the following lab hours:
EC 2990 - project course, do not schedule
EC 3370 (If not Prof. Kraus', make inquiry to prof.)
EC 4450, EC 4560, EC 4470 (if EC/ZM lab may be unsch.)
EC 4820, EO 3740

L-2

DEPT	CLASS	#STU	LECT	LAB	SECT
AS	AS3611	16	4	1	
	CM0001	4	0	2	
	CM0810	2	0	0	
	IS0001	129	0	2	
	IS0810	39	0	0	
	IS2000	33	3	1	
	IS3170	60	4	0	
	IS3183	122	4	0	
	IS4183	63	4	1	
	IS4200	61	4	0	
	IS4300	37	4	0	
	IS4320	34	4	0	
	IS4800	2	V	0	
	MN0001	230	0	2	
	MN0810	73	0	0	
	MN2112	13	0	2	
	MN2155	34	4	0	
	MN2302	48	0	2	
	MN2303	8	0	2	
	MN3105	32	4	0	
	MN3111	32	4	0	
	MN3140	73	4	0	
	MN3154	106	4	0	
	MN3161	75	4	0	
	MN3172	31	4	0	

STUDENT CARDS COLOR ON THE RIGHT HAND SIDE				
	COLOR	DEPT	STUDENT CODE	CODE
	BROWN	OP ANAL	G, R	CODE 30
	YELLOW	AERO ENGR	A	CODE 31
	ORANGE	AIR-OCEAN SCI	X, O	CODE 35
	PURPLE	ADMIN SCI	M	CODE 36
	PINK/GREEN	COMP TECH	C, P	CODE 37
	RED	NAVL INTEL	Y	CODE 38
STUDENT CARDS COLOR ON THE CENTER				
	PURPLE/PINK	ASW/ELEC WARFARE	I, K	CODE 3A
	BLUE	ELEC/COMM	D, E H	CODE 32
	BLACK	WPNS ENGR	U, W	CODE 33
	GREEN	NAV ENGR	N	CODE 34
	RED	JT C3/SPACE	J, SE, SO	CODE 39

NAME / CODE | AVIATORS | STUDENTS | TERM | YEAR

	1 0810-0900	2 0910-1000	3 1010-1100	4 1110-1200	5 1210-1300	6 1310-1400	7 1410-1500	8 1510-1600	9 1610-1700
MON									
TUE									
WED									
THUR									
FRI.									
	1 0810-0900	2 0910-1000	3 1010-1100	4 1110-1200	5 1210-1300	6 1310-1400	7 1410-1500	8 1510-1600	9 1610-1700

SCHEDULING WORKSHEET NPGS-5300/1(7-69)

11 AS/H3 HAGA, WILLIAM AS Winter Qtr 92/2

	1	2	3	4	5	6	7	8	9	
MONDAY			IS 4182 I-279, 280 [final-in red]							MONDAY
TUESDAY	IS 4182-1 ✓ I-280 27 ✓					IS 4182-2 ✓ I-280 26 ✓				TUESDAY
WEDNESDAY										WEDNESDAY
THURSDAY	IS 4182-1 ✓ I-280 ✓					IS 4182-2 ✓ I-280 ✓		Dept. Mtg.		THURSDAY
FRIDAY										FRIDAY

GROUP ROOM PROFESSOR CARD

IS 4182 (4-0) 2 segments of 2

U.S. Government Printing Office 1983 691 385

119. KFII 2 5 STUDENTS AW QTR 2 91-92

	1	2	3	4	5	6	7	8	9
MONDAY	PH 4209					EC 3620	[Final] PH 4209		
TUESDAY	PH 4209	[final-mid] EC 4620	EC 4620					LECTURE PROGRAM	EC 3620 EC 4620 EW 0002 EW 0810 PH 4209
WEDNESDAY	PH 4209 EC 3620					EC 3620	EC 4620 LAB		
THURSDAY	PH 4209					EC 3620		EW 0002	
FRIDAY								EC 3620	

KFII 2 EC362032---EC462032---EW000201---EW081000---PH420932---
CHANG TC CHI YK LI CK THONGRGOD A WU TL

8

	1	2	3	4	5	6	7	8	9
MONDAY	EO 6 2740 EC/BG		EC 4580 14 EC/LA			OC 13 3230-2 OC/BV	PH 11 4353 PH/ZL		
TUESDAY					OC 3230-2 OC/BV				
WEDNESDAY				CS4313 CS/KA 8		OC 3230-2 OC/BV			
THURSDAY						OC 3230-2 OC/BV		EC 3650 EC/AB 8	
FRIDAY			CS 4313 CS/KA					EC 4580 EC/LA	

GROUP ROOM PROFESSOR SCHEDULE
S-226 20 T WINTER 92

2 LAB

	1	2	3	4	5	6	7	8	9
MONDAY							PH 4454-A PH/WL	8	
TUESDAY									
WEDNESDAY						PH 3402 PH/CZ	7		
THURSDAY									
FRIDAY							PH ~~4454-B~~ PH/WL	9	

S-019, 025 no two diff classes on same day Acoustics, Moore X2781 WINTER 92

7

	1	2	3	4	5	6	7	8	9
MONDAY			PH2511 PH/ZL			OC 4211 OC/CW			
TUESDAY			[all finals - in red]			PH 3352 PH/GM			
WEDNESDAY	PH 3252 PH/CR					SE 4006 PH/WH			
THURSDAY			PH 2724 PH/BA						
FRIDAY									

S-226 21 T WINTER 92

MASTER INSTRUCTION SCHEDULE

NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIFORNIA

EFFECTIVE 6 JAN - 26 MAR 92
FINAL EXAM PERIOD 23 MAR - 26 MAR 92

WINTER QUARTER AY 1992

COURSE	CR HOURS	NO. STU	PROF	MONDAY PERIOD	MONDAY ROOM	TUESDAY PERIOD	TUESDAY ROOM	WEDNESDAY PERIOD	WEDNESDAY ROOM	THURSDAY PERIOD	THURSDAY ROOM	FRIDAY PERIOD	FRIDAY ROOM
INTERNATIONAL PROGRAMS													
IT1500	3-0	11	XX/KZ	8	I-379			8-9	I-379				
ADMINISTRATIVE SCIENCES (AS)													
AS1701	4-0	6	AS/DR	4	I-380	4	I-380	4	I-380	4	I-380		
AS2701	4-0	6	AS/DR	1-2	I-379			1-2	I-379				
AS3610	4-0	19	AS/MN	5	I-267	5	I-267	5	I-267	5	I-267		
			EXAM	1-2	I-263								
CM0001	0-2	27	AS/BO							8-9	I-265		
CM4925	4-0	24	AS/SG			1-2	I-267			1-2	I-267		
IS0001	0-2	173	37/--							8-9	S-321		
IS0123-1	0-2	13	AS/LI			3-4	I-250						
IS0123-2	0-2	14	AS/LI			6-7	I-250						
IS0123-3	0-2	14	AS/LI					8-9	I-250				
IS0123-4	0-2	12	AS/LI							3-4	I-250		
IS0123-5	0-2	12	AS/LI							6-7	I-250		
IS0123-6	0-2	15	AS/LI									3-4	I-250
IS0123-7	0-2	14	AS/LI									8-9	I-250
IS3502-1	4-0	22	AS/SS	1	I-119,224,250	1	I-119,224,250	1	I-119,224,250	1	I-119,224,250		
IS3502-2	4-0	22	AS/SS	2	I-119,224,250	2	I-119,224,250	2	I-119,224,250	2	I-119,224,250		
			EXAM	6-7	I-280,282								
IS3503	3-0	28	AS/SS	3	I-119,224,250			3	I-119,224,250			2	I-119,224,250
IS3503	0-2	28	AS/SS									6-7	I-119,224,250
			EXAM			1-2	I-322						

NAVAL POSTGRADUATE SCHOOL
INSTRUCTION STAFF
(Unofficial Listing - December 1991)

034
AVIATION SAFETY

BA	BARCLAY, DANA D.
BT	BANK, MILTON H.
BZ	BULWICZ, STEVEN
CI	CIAVARELLI, ANTHONY P.JR.
FI	FIGLOCK, ROBERT
KF	KENNEDY, E. JOHN
MO	MORAN, ROBERT
NA	NATION, CHARLIE
PI	PICKETT, CHARLES D.
RG	RYGG, RONALD F.
ST	SCHRECKENGAST, STEWART W.
TO	TOFT, RICHARD
YA	YASMENT, FRANK

AA
AERO/ASTRO ENGRG

AG	AGRAWAL, BRIJ
BI	BIBLARZ, OSCAR
BP	BALL, ROBERT E.
CH	CHANDRASEKHARA, M
CO	COLLINS, DANIEL J.
GO	GORMAN, MICHAEL R
HB	HEBBAR, SHESHAGIRI K
HE	HEALEY, JAMES V
HG	HOBSON, GARTH
HO	HOWARD, RICHARD M
HS	HAUSER, JAMES P
KJ	KOLAR, RAMESH
LE	LEE, TAE-HO
LI	LINDSEY, GERALD H.
NA	NATAN, B
NE	NEWBERRY, CONRAD F.
NT	NETZER, DAVID W.
PA	PAGENKOPF, ERIC
PL	PLATZER, MAXIMILIAN F.
RO	ROSS, I. MICHAEL
SC	SCHMIDT, LOUIS V.
SF	SHREEVE, RAYMOND P.
SW	SWEENEY, JOSEPH LCDR
WD	WOOD, E. ROBERTS
WU	WU, EDWARD M.

AS
ADMIN SCIENCES

AH	ABDEL-HAMID, T.
AL	ALLION, DENNIS G., CDR
BC	BARRIOS-CHOPLIN, ROBERT
BD	BUI, TUNG X.
BH	BHARGAVA, HEMANT
BO	BOGER, DAN C.
BR	BARRETT, FRANK

AS
ADMIN SCIENCES (Cont.)

BU	BUCHNER, SUSAN
BZ	BROWN, DAVID
CA	CARRICK, PAUL M.
CH	CHASE, GLEN
CR	CRAWFORD, ALICE
DK	DOLK, DANIEL R.
DR	DRESSER, CYNTHIA H.
DY	DOYLE, RICHARD
EB	EITELBERG, MARK J.
EE	EUSKE, KENNETH J.
EL	ELSTER, RICHARD S.
ER	EBERLING, GLEN CDR
EV	EVERED, ROGER D.
EY	EMERY, JAMES
FA	THOMAS, GAIL FANN
FM	FREMGEN, JAMES M.
FT	FITZGERALD, DAVID M.
FW	FREW, BARRY A.
GR	GORMAN, LINDA
GT	GATES, WILLIAM
HA	HARSHMAN, RICHARD
HC	HOCEVAR, SUSAN
HG	HAGA, WILLIAM J.
HN	HORTON, FENN C.
HO	HOIVIK, THOMAS H.
HR	HARRIS, RUEBEN
HT	HENDERSON, DAVID R.
JN	JONES, LARRY
JS	JONES, CARL R.
KA	KAMEL, MAGDI
KK	KANG, KEEBOM
KT	KNIGHT, ROBERT L.
KU	KUMARASAMY, SHANTHI
LC	LIAO, SHU S.
LI	LINDSAY, E. CARYL
LT	LAMM, DAVID V.
MB	MCGONIGAL, RICHARD A.
MF	MCCAFFREY, MARTY
MG	MCMASTERS, ALAN W.
MI	MITCHELL, CAROL
MM	MCCAFFERY, JERRY L.
MO	MOSES, DOUGLAS
MP	MEHAY, STEPHEN L.
MR	MOORE, THOMAS P.
MT	MEANS, TOM
MY	MATSUSHIMA, RODNEY F.
NE	NEVELS, JEFFREY
RA	RAMESH, BALA
RC	ROBERTS, NANCY C.
RO	ROBERTS, BENJAMIN J.
SA	SUCHAN, JAMES E.
SD	SRIDHAR, SURESH
SE	SENGUPTA, KISHORE
SG	SESSIONS, STERLING
SM	SAN MIGUEL, JOSEPH

CHANGE OF REGISTRATION FORM

STUDENT'S LAST NAME FIRST NAME MIDDLE INITIAL — SSN — CURRICULUM #

STUDENT'S SIGNATURE — DATE

ACADEMIC ASSOCIATE'S SIGNATURE — DATE

CURRICULAR OFFICER'S SIGNATURE — DATE

CURRICULAR OFFICE CODE:

CHANGE OF REGISTRATION FOR:

Academic Year: ________

Academic Quarter (Please Circle Below):

[OCT-DEC]	[JAN-MAR]	[APR-JUN]	[JUL-SEP]
1	2	3	4

NOTE: **Change of Registration Forms must have the APPROVAL SIGNATURES of both the Academic Associate and Curricular Officer PRIOR to being taken to the individual Professors/Instructor for signature.**

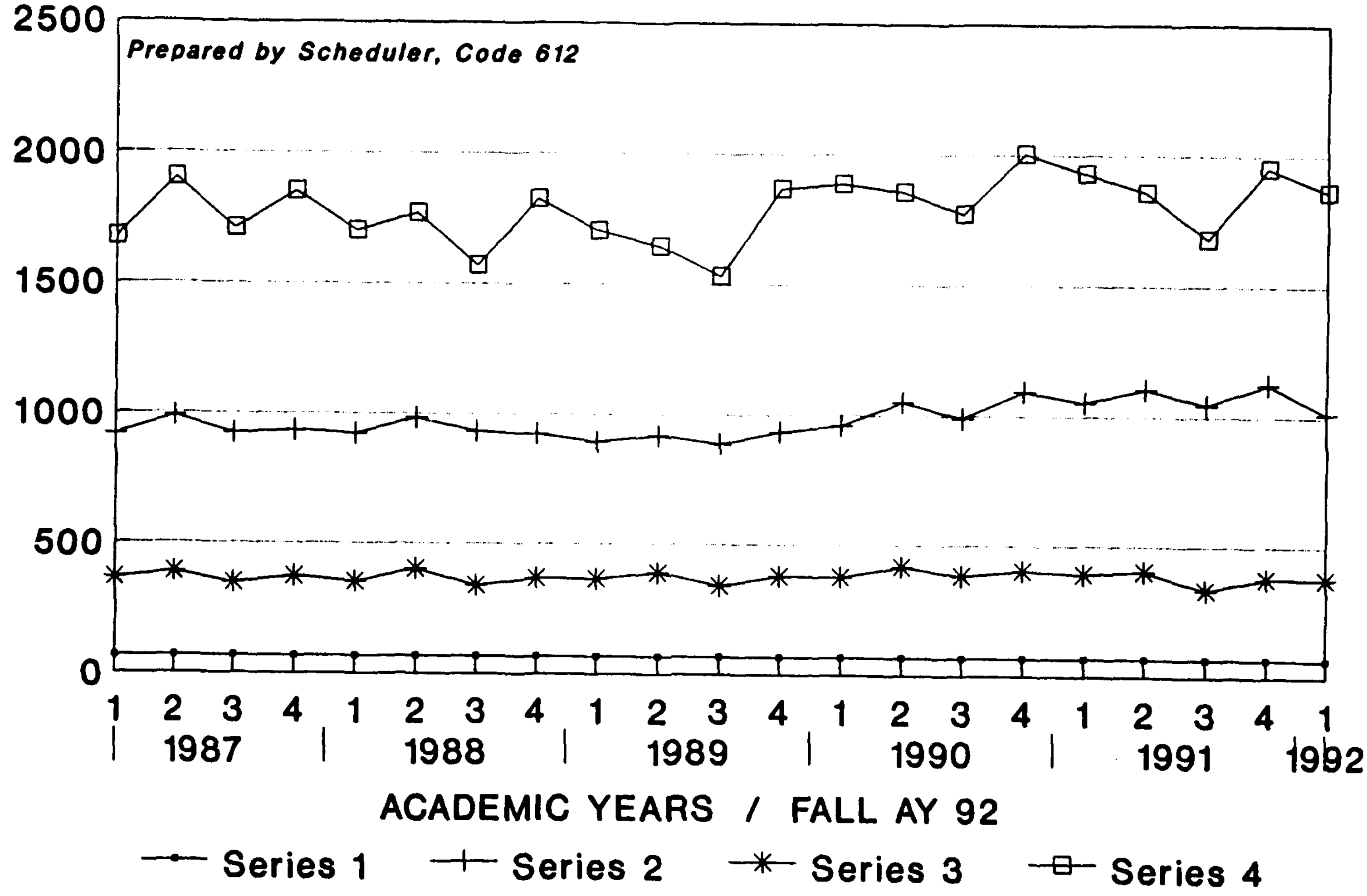
COURSE WITHDRAWALS (DROPS)

COURSE Number	SEGMENT Number	Professor/Instructor's NAME (print legibly)	Professor/Instructor's SIGNATURE	DATE (DD/MM/YY)
				/ /
				/ /
				/ /
				/ /
				/ /

COURSE ENROLLMENTS (ADDS)

COURSE Number	SEGMENT CREDITS	Professor/Instructor's NAME (print legibly)	Professor/Instructor's SIGNATURE	DATE (DD/MM/YY)
	__ . __			/ /
	__ . __			/ /
	__ . __			/ /
	__ . __			/ /
	__ . __			/ /

SCHEDULING DATA



CLASSROOMS AVAILABLE-SER 1, Qtr 1/92=66

STUDENT CLIQUES-SER 2, Qtr 1/92=1013

COURSES OFFERED-SER 3, Qtr 1/92=377

STUDENT ENROLLMENT-SER 4, Qtr 1/92=1863

NPS STUDENTS QUARTERLY ENROLLMENT BY CURRICULUM SPECIALTY

CURRICULUM SPECIALTY NUMBER ____ QUARTER ____ AY ____

A. INSTRUCTIONS
1. USE A SEPARATE SHEET FOR EACH CURRICULUM SPECIALTY NUMBER
2. * THE VERTICAL AND HORIZONTAL TOTALS OF RIGHTMOST COLUMN SHOULD BE EQUAL
3. LIST TRANSFER IN/OUT BY NAME ON BACK IF OTHER THAN 460 FOR THIS CURRIC SPECIALTY
4. CALL WHEN READY FOR PICK UP (2773) BY END OF 2ND WEEK OR FOR ANY QUESTIONS
5. DO NOT SEND BY GUARD MAIL

AS OF DATE ____ DAY MO YR (FRIDAY OF 2ND WEEK OF QTR)

NOTE: INCLUDE ALL STUDENTS UNDER INSTRUCTION BUT DO NOT INCLUDE STASHES

B. REPORT 1. IN CURRICULUM SPECIALTY NUMBER ____

SERVICE	UNDER INSTRUCTION LAST QTR	− ATTRITES (ACADEMIC VOLUNTARY) (1)	− DETACHED / COMPLETED		INTERCURRIC TRANSFERS		= TOTAL CARRY OVER	+ INPUT STARTING THIS QTR (3)	= UNDER INSTRUCTION THIS QTR
			NON DEGREE PROGRAMS	DEGREE PROGRAMS (2)	− OUT	+ IN			
USN									
MC									
AR									
AF									
CG									
NOA									
CIV									
INTL									
TOTAL									*

2. IN ENGINEERING SCIENCE (460) FOR CURRICULUM NUMBER ____ (IF APPLICABLE TO ABOVE SPECIALTY)

SERVICE	UNDER INSTRUCTION LAST QTR	− ATTRITES	− NON DEGREE PROGRAMS	− DEGREE PROGRAMS	− OUT	+ IN	= TOTAL CARRY OVER	+ INPUT STARTING THIS QTR	= UNDER INSTRUCTION THIS QTR
USN				—					
MC				—					
AR				—					
AF				—					
CG				—					
NOA				—					
CIV				—					
INTL				—					
TOTAL				—					*
GRAND TOTAL									*

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NETC
Newport, Rhode Island 02841-5012

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Computer Science Department
Naval Postgraduate School
Monterey, California 93943-5000